MODERN PLASTICS

ENCYCLOPEDIA ISSUE FOR 1960

SEPTEMBER 1959

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FOREWORD

Keeping pace with an industry that is bursting out in every direction with new developments in every area, the editors of the Modern Plastics Encyclopedia Issue have come up with a record number of new features and articles to adequately cover the year's activities. A few examples:

In the Resins and Molding Compounds section, articles on the newer resins, including the acetals, polycarbonates, and polypropylenes, have been installed as permanent features, while extensive revision by individual plastics experts has brought all the articles on the older materials up-to-date. A special feature (p. 97) lists the types and grades of polyethylene commercially available from suppliers.

The Foamed Plastics section has been re-arranged and expanded to provide for easier extraction of pertinent data—and a special 4-page Recent Development feature offers a concise running commentary on "what's new in the field."

In other sections pertaining to chemicals, film and sheeting, reinforcements, and laminates, readers will find new articles devoted to such timely topics as ultra-violet light absorbers; how to use and store plastic film, sheeting, and shapes to reduce spoilage and waste; sisal fibers in their new role as reinforcing materials; and what reinforced plastics processors should know about the three most recent processing techniques; centrifugal casting, filament winding, and spray-up molding.

The up-dated Plastics Properties Chart—in the same colorful, simplified form that proved so popular last year—and the 64-page Technical Data Charts Section are invaluable reference sources. And this year we've trained our chart-making

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abilities on an entirely new subject—processing equipment. A 56-page section of charts gives detailed specifications on commercially available injection molding, compression molding, extruding, and thermoforming machines.

The processing data that appears in the Engineering and Methods section also came in for extensive revision, with particular attention to the newer plastics materials: polypropylene, polycarbonate, rigid vinyls, acetal resins, the modified acrylics, the new nylons, and the FEP resins. In the Fabricating and Finishing section, decorating and assembling of plastics products has been given broader treatment; in the Machinery and Equipment section, variable speed drives, temperature control units, granulators and pelletizers, weigh feeders, hopper dryers, and water recovery systems are among the many pieces of auxiliary equipment to which special editorial space has been devoted.

On p. 1063 begins a 12-page section listing the titles and describing 468 booklets, brochures, catalogs, and technical bulletins available gratis from manufacturers. The Directory Section starting on p. 1078 gives an up-to-date, authoritative listing of manufacturers, molders, suppliers, distributors, etc., as well as a list of Trade Designations.

In using this Encyclopedia Issue, readers are advised to check first with the Table of Contents on p. 4 for the over-all breakdown; the key Index on p. 6 gives a complete guide as to *what* specific information is located *where*. In addition, an Index of Advertisers whose products and/or services are related to the subject matter of individual sections can be found at the beginning of each section. Page numbers for these Indexes are listed on pgs. 4 and 5.

The compilation of this year's Encyclopedia Issue was a twelve-months job requiring the services of a special editorial organization set up specifically for this purpose. We feel the results have well warranted the effort and that the Encyclopedia Issue is still the most inclusive and invaluable reference work on plastics available.

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Cleworth Publishing Co., Inc., 551 Fifth Ave., New York 17, N. Y.
Cornell University Press, 124 Roberts Place, Ithaca, N. Y.
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STATISTICS OF THE INDUSTRY

Synthetic plastics and resin production, dry basis[a] (U.S. Tariff Commission)

Material	*1957*	*1958*
	1000 lb.	*1000 lb.*
CELLULOSE PLASTICS:		
Cellulose acetate and mixed ester:		
Sheets, under 0.003 gage	18,568	17,035
Sheets, 0.003 gage and over	18,448	18,421
All other sheets, rods, and tubes[b]	7,573	9,193
Molding and extrusion materials[b]	94,193	93,772
Nitrocellulose sheets, rods, and tubes	3,972	2,937
Other cellulose plastics	5,358	—
Total	148,112	141,358
PHENOLIC AND OTHER TAR ACID RESINS:		
Molding materials	183,886	169,133
Bonding and adhesive resins for:		
Laminating (except plywood)	69,198	64,386
Coated and bonded abrasives	16,787	12,548
Friction materials (brake linings, clutch facings, etc.)	15,334	13,474
Thermal insulation (rockwool, fibrous glass)	53,215	46,656
Plywood	46,887	51,411
All other bonding and adhesive uses	51,169	41,364
Protective coating resins, unmodified and modified, except by rosin	31,111	28,693
Resins for all other uses	40,071	32,944
Total	507,658	460,609
UREA AND MELAMINE RESINS:		
Textile-treating and textile-coating resins	41,160	33,215
Paper-treating and paper-coating resins	23,942	24,809
Bonding and adhesive resins for:		
Plywood	98,115	100,406
All other bonding and adhesive uses, including laminating	41,054	43,395
Protective coating resins, straight and modified	36,860	31,832
Resins for all other uses, including molding	107,946	90,509
Total	349,077	324,166
POLYESTER RESINS:		
Reinforced plastics	87,466	98,098
All other uses	8,766	15,764
Total	96,232	113,862
STYRENE RESINS:		
Molding materials	422,082	442,211
Protective coating resins, straight and modified[c]	91,641	96,805
Resins for all other uses	159,602	156,351
Total	673,325	695,367
POLYETHYLENE	707,500	864,001
VINYL AND VINYL COPOLYMER RESINS[d] (resin content):		
Polyvinyl chloride and copolymer resins (50% or more PVC) for:		
Film (under 0.010 gage)	78,029	71,326
Sheeting (0.010 gage and over)	62,571	69,144
Molding and extrusion	218,466	214,366
Textile- and paper-treating and coating	68,446	63,048
Flooring	81,248	113,584
Protective coatings	31,374	28,921
All other uses	94,308	69,533
All other vinyl resins for:		
Adhesives	41,965	47,994
All other uses	120,423	123,200
Total	886,506	821,369
ALKYD RESINS:		
For protective coatings:		
Phthalic anhydride types:		
Unmodified	314,434	235,787
Modified	118,094	66,815
Polybasic acid types:		
Unmodified	7,551	5,068
Modified	19,240	11,690
For all other uses	27,567	18,929
Total	486,886	338,289
ROSIN MODIFICATIONS:		
Rosin esters for protective coatings:		
Unmodified (estergums)	32,428	23,798
Modified (hard resins)	60,762	55,743
All other modifications for protective coatings and other uses	28,540	40,737
Total	121,730	120,278
COUMARONE-INDENE AND PETROLEUM POLYMER RESINS	286,144	236,837
MISCELLANEOUS SYNTHETIC PLASTICS AND RESINS:[e]		
Molding materials	52,834	45,884
Protective coating resins	42,730	18,666
Resins for all other uses	130,028	144,103
Total	225,592	208,653
GRAND TOTAL	4,488,762	4,324,789[f]

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[a] "Dry basis" is defined as the total weight of the material, *including* resin, plasticizers, fillers, extenders, colors, and stabilizers, and *excluding* the weight of water, solvents, and other liquid diluents.

[b] Including other cellulose plastics in 1958.

[c] Includes data for styrene-alkyd polyester resins.

[d] Statistics by use are based on sales; total is based on production.

[e] Includes data for acrylic, epichlorohydrin, polyamide (nylon), silicone, and various other types of synthetic plastics and resin materials.

[f] 1958 figures are those released Mar. 20, 1959. Revised figures too late to include above, give 1958 grand total as 4,658,987,000 pounds.

PRIMER OF PLASTICS

The accepted definition of plastics is: "a large and varied group of materials which consist of, or contain as an essential ingredient, a substance of high molecular weight which, while solid in the finished state, at some stage in its manufacture is soft enough to be formed into various shapes, most usually through the application, either singly or together, of heat and pressure."

Most plastics, with the exception of the cellulosics, which are chemically modified natural high polymers made from cotton, are produced by synthesis from such natural resources as water, air, coal, salt, natural gas, etc. From these are derived the various chemicals and gases which are combined to produce the plastics materials. As an example, the raw materials for making polystyrene, one of the most important of the plastics, are coal and petroleum or natural gas. By a process of distillation, benzene is extracted from the coal; from the petroleum or natural gas is taken the gas ethylene. These two materials are then linked to form ethyl benzene which is dehydrogenated to styrene. With the aid of catalysts, heat, and pressure, thousands of styrene molecules polymerize, or link together, to form long chain-like molecules that clump into small granules of crude polystyrene. These grains are hot-worked and cut into small pellets called molding powder, the most common form in which plastics are supplied.

Because of the many source materials which the chemist has at his command, and because so many different combinations are possible, the family of plastics today encompasses a large—and still growing—number of members, all of which differ in properties and characteristics. If, for example, the ethylene gas used in producing polystyrene were combined with chlorine (from salt) and then polymerized, the result would be polyvinyl chloride—a very different plastic.

Major Subdivisions

Many combinations and many different materials are thus possible. Therefore, for purposes of simplification, most plastics can be classified under one of the 14 recognized basic family groups. These groups, in turn, can be *generally* further classified under one of two major subdivisions—thermosetting or thermoplastics. A few plastics are in-between—they can be formulated either to be thermosetting or to be thermoplastic.

The thermosets, as the term implies, set or harden (cure) under heat into a permanent shape. An irreversible chemical reaction called cross-linking occurs; this reaction links the resin chains so that the molded piece is essentially one giant, three-dimensional molecule. Subsequent heating, though it may soften the structure somewhat, cannot restore the flowability that typifies the uncured resin. In this classification are such basic family groups as the aminos (melamine and urea), most polyesters, alkyds, epoxies, and phenolics.

The thermoplastics, on the other hand, soften when heat is applied and harden upon cooling. By alternate heating and cooling, they can be reshaped again and again (just as a cake of ice melts in the sun and the resulting water can be solidified into a different shape by freezing). Thermoplastics include styrene polymers and copolymers, acrylics, cellulosics, polyethylenes, vinyls, nylons, and fluorocarbons.

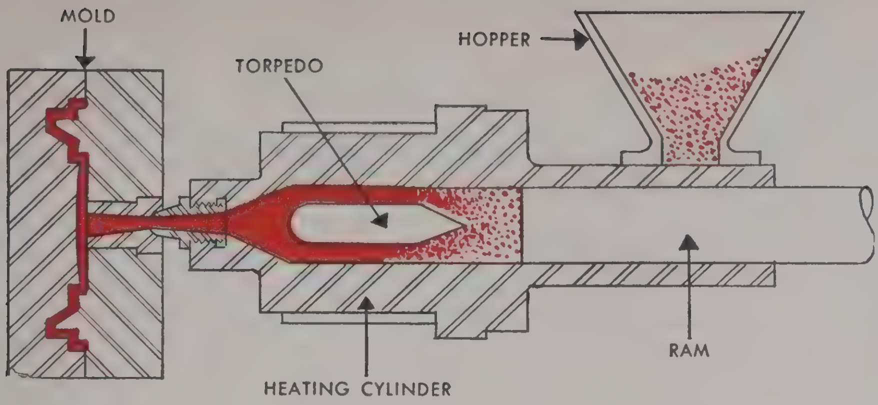
Alloying of plastics yields new types of materials with intermediate physical and chemical properties. Similarly, plastics can be combined with other materials to create a new end-product having the advantages of both. Important examples are the blends of styrene-acrylonitrile or styrene-butadiene resins and rubbers which exhibit the hardness and high resistance of the resin and the toughness and low brittle point of the rubber. By copolymerizing (polymerizing together) two monomers, products similar to the alloyed polymers can be obtained, often at less expense.

Processing Methods

Before they are processed, most basic plastics resins can be combined—compounded—with any one of a large range of modifying chemicals or reinforcing materials in varying proportions to achieve a given end result. Such additions can take the form of plasticizers (which soften the plastic and make it more flexible), stabilizers (which prevent degradation in the plastic when it is exposed to heat or light), fillers (which add bulk and reduce over-all costs), colorants (which add integral color to the processed plastic end-product), and reinforcing fibers (which improve impact strength, electrical properties, etc., of finished product). Solvents are used in plastics compositions to give the degree of temporary fluidity necessary to such operations as dipping, brushing, spraying, etc., and catalysts are often added to speed up the cure of a compound.

After compounding, the resultant plastics are supplied in convenient liquid, granular, or powdered forms to processors.

From granular or powdered form, they are



INJECTION MOLDING: Molding powder (shown in color) is fed from the hopper to the cylinder and moved forward by the ram into the heating cylinder, where it melts and is forced around the torpedo, through the nozzle, and into the mold

softened and shaped by molding or extrusion. They can also be transformed into flexible film or sheeting by extrusion or calendering. Sheets, in turn, may be resoftened and shaped into contours.

In liquid form, the plastics are used as spray-on, dip-on, and brush-on coatings, or incorporated into lacquers, paints, and adhesives. Plastic-based bonding agents are among the best. Liquid plastics are also cast into sheets.

By mechanical mixing or by the addition of chemical blowing agents, liquid plastics resins can also be foamed into a cellular product for insulation, cushioning, flotation applications, etc.

Of these methods of processing, molding consumes the largest volume of material. Molding procedures are all based on the fact that, when the plastic is heated, it will melt to a viscous liquid that can be forced into a mold of desired shape, where it solidifies.

Injection Molding

Different molding processes have been developed to handle the specialized properties of the various plastics. Injection molding, for example, is the most commonly used method for producing thermoplastic end-products.

In injection molding, pellets are first fed from a hopper into the rear end of a heating cylinder where heating starts. With successive strokes of an injection ram the material is compacted and forced forward through a thin annular space between a heated "torpedo" in the center of the cylinder and the cylinder walls. There the material is melted. Soon it reaches the cylinder nozzle and is injected into a cold mold.

The fluid plastic completely fills the mold cavity, which is shaped to the contours of the finished product. When the plastic has cooled and solidified, the mold is opened and the finished piece, an exact image of the mold cavity, is ejected.

To speed up molding cycles and facilitate production, preplasticators are available. A preplasticator is simply an auxiliary heating cylinder which melts the granules and transfers the melt to the injection cylinder where it is further heated and held ready for injection.

Compression Molding

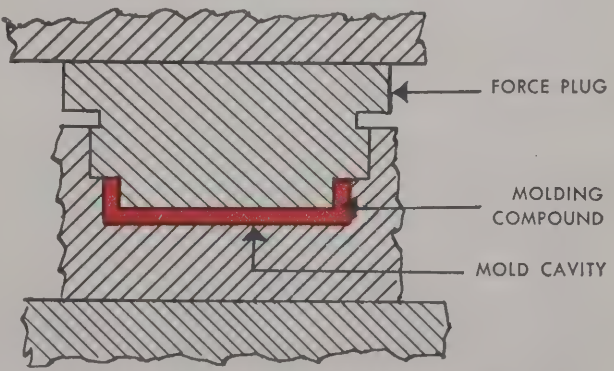
For molding the thermosetting plastics, the method most generally used is compression molding. The basic procedure is to place the molding compound (generally preheated) in the open mold cavity, close the mold, and then apply heat and pressure (through a downward-moving force plug) to the material until it softens and is forced to fill the mold cavity. In the closed mold, the material undergoes a chemical reaction that cross-links the polymer chains and thus hardens into a permanent shape. The mold is then opened and the solid piece is removed.

Transfer (closed mold or plunger) molding is a variation of compression molding in which the heat and pressure are applied to the molding material in a pot outside the mold. The fluid material is then forced by a plunger through channels (runners) from the external chamber to the closed mold cavity where final cure takes place.

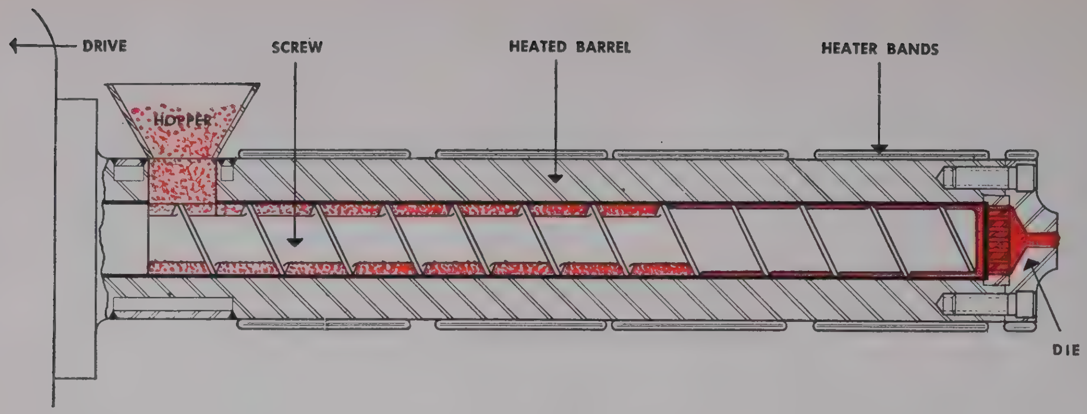
Extrusion

For the production of continuous film, sheeting, rods, tubes, and other profile shapes (as distinguished from molded shapes), extrusion, another of the major processing divisions, is the method commonly employed.

In extrusion, the powdered or granular material is fed through a hopper at the rear of the unit into a heated barrel where it is plasticated by heat and



COMPRESSION MOLDING: Simplified drawing of mold shows the two parts (force plug and cavity) in closed position with material fully compressed. Prior to this stage, the loose material, usually preheated to promote flow under pressure, was placed in the open cavity. The mold was then closed and heat and pressure were applied. After the material hardens (cures) the mold is opened and the finished plastic part is removed from the cavity



EXTRUSION: Plastic compound, shown in color, feeds from the hopper into the threads of a revolving screw. This screw serves to transport the material through the heated barrel, working it at the same time. The softened plastic finally reaches the die, which forms it to the desired shape as it emerges under pressure

working. The hot melt is then forced forward by a continuously revolving screw through a heating chamber and out through a shaping orifice or die, much as meat is forced through a grinder. As the plastic shape, which can be anything from a thick rod or large pipe to a thin sheet or thread-like monofilament, depending upon the size and shape of the die, is forced out, it is usually conveyed through a water bath that sets the shape.

Plastics can also be extruded as coatings around continuous lengths of wire or cable.

While these three techniques—injection, compression, and extrusion—account for the production of the major share of plastics products, other variations in molding techniques are possible. In blow molding, for example, which is used in the production of plastics bottles, thermoplastics sheets or charges from an extrusion machine are placed in closed molds and are forced into final form by being blown into these molds with air or steam pressure. Pulp molding and jet molding are other techniques used for specialized applications.

Casting

Although the above molding methods differ in many respects from each other, they all have one thing in common—the use of heat and external pressure. Where no pressure is used, the process is known as casting. In casting, the plastic (either thermoplastic or thermosetting) is supplied in liquid form or in granular or powdered form that can be liquefied by heating or by the addition of solvents, catalysts, etc. The fluid plastic is poured into a mold and is cured into a solid at room temperature or by further heating.

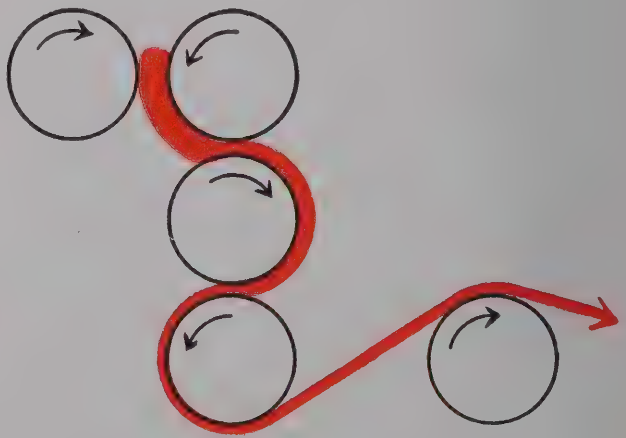
Many variations in casting techniques are also possible. One method used for making flexible toys, overshoes, etc., is slush molding, in which a thermoplastic resin slurry (or "slush") is poured into a warm mold. The heat homogenizes the slurry into a viscous layer of the desired wall thickness, and the excess slurry is then poured out. The resin left in the mold is fully fused by additional heat, then chilled; in its final flexible form, it is simply stripped out of the mold.

Casting is also involved in one of the other two techniques which, in addition to extrusion, are available for the production of plastics film and sheet (film generally refers to sheeting 0.010 in. and thinner). When casting film or sheet, the liquid plastics material is cast on a moving belt or by precipitation in a chemical bath.

Calendering

The third major technique for turning out film and sheet is known as calendering. In calendering, the plastics compound, usually in the form of a warm doughy mass, is passed between a series of heated rollers, where it is thoroughly worked. It emerges from the rolls squeezed into flat film or sheet, the uniform thickness of which is determined by the gap between the last pair of rolls (gaging rolls), and is cooled on a chill roll.

Calendering can also be used to apply a plastic covering to such backing materials as paper, fabric, etc. The film and backing material are simply



CALENDERING: Plastic compound (color) is fed into the space between the two top rolls, and passes downward between other rolls where it is thoroughly worked. It emerges from the calender train in a flat film or sheet, the thickness of which is controlled by the final pair of rolls, only one of which is shown here. The finished sheet is cooled by passing it over a chill roll squeezed together in the heated rollers, with resulting fusion.

Fabricating and Finishing

After plastics film, sheet, or extruded or molded shapes have been produced, additional operations are sometimes necessary before the final plastics product is ready for market. These operations generally fall under the classification of either "fabricating" or "finishing," or both. Fabricating rigid plastics involves changing the size or the shape of the molded or extruded piece, adding holes or openings, etc., by such conventional metal- or woodworking techniques as drilling, tapping, turning, milling, etc. Fabricating flexible plastics film or sheeting involves cutting the material to size (film and sheeting are generally produced in continuous rolls or are available in stock sheet sizes) and turning it into an end product by sewing, heat-sealing to itself or to other materials, etc.

The term "finishing" is generally applied to operations (e.g., tumbling, sanding, etc.) for improving the surface appearance of molded plastics pieces by removing flash (excess material at the parting line) and other extraneous matter, as well as to the various decorating techniques used. When working with rigid plastics, surface decoration can take the form of stamping, printing, spraying, or vacuum metalizing (in which a metal coating is deposited on the plastic). Film, sheet, or coated materials can be metalized, printed with colorful patterns, or embossed or flocked to simulate virtually any type of surface texture.

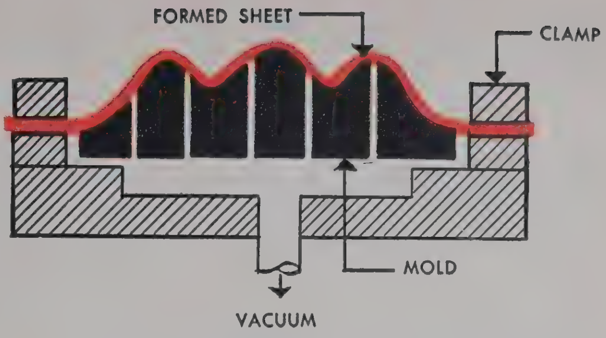
Sheet Forming

One of the most important fabricating operations —and one that has virtually grown into an entire industry of its own—is that of heat-forming film or sheeting. The basic principle is: heat-softened film or sheet is forced against a cold mold and permanently takes on the contours of the mold. A wide range of forming methods have been developed, differing primarily in the manner in which the sheet is heated and pressure is applied.

Laminates and Reinforced Plastics

Many plastics, usually liquids at room temperature, are used as binders and surfacing materials in conjunction with reinforcing materials such as fibrous glass, synthetic fibers, paper, wood, etc. Uses for plastics in this area divide into three basic categories: surface coating materials (paints, varnishes, lacquers, and coatings for fabrics, paper, etc.); bonding materials (including resins to bond sand in the manufacture of foundry cores and abrasives in the manufacture of grinding wheels, etc.); and laminating materials.

For purposes of simplification, the latter classification can be further broken down into two main product groups—high-pressure laminates and low-pressure laminates. As the names imply, the difference is in the amount of pressure used in processing, but the gap is closing and higher and higher pressures are being used to produce better and better "low-pressure" laminates. The latter are commonly referred to as "reinforced plastics."



SHEET FORMING: Plastic sheet can be formed to a wide variety of complicated shapes by various methods, all of which involve softening the plastic with heat and then forcing it to conform to the contours of a mold. One method of applying pressure to the sheet is by pulling a vacuum, as shown above. Other methods use compressed air or combinations of air pressure, vacuum, and mechanical assists

In making a high-pressure laminate, sheets of the reinforcing material are impregnated with the liquid plastic resin and subjected to heat and high pressures while they cure into a single piece of uniform thickness. High-pressure laminates are subdivided into decorative laminates, such as are used for counters and tabletops, and industrial laminates, which are machined into such industrial components as gears and bearings.

In molding reinforced plastics, woven cloths or nonwoven mats of the reinforcing material (glass, synthetic fibers, asbestos, etc.) are also impregnated with resin, but the laminate can be cured with little or no pressure. Molding a reinforced plastic product can be as simple as placing pre-cut pieces of reinforcing materials in an open mold, impregnating them with liquid plastic, and curing at room temperature and atmospheric pressure. However, the use of closed "matched metal" molds in heavy compression presses is becoming common.

Combinations of Materials

To obtain the individual advantages of different plastics materials in a single product, techniques have been developed for combining materials. Laminating, for example, using heat and pressure, can be used for uniting different types of plastics film and sheeting.

"Sandwiches" are another combination material for which many uses are predicted. A sandwich construction is a multi-layered laminate formed by bonding (generally with synthetic resin adhesives) two thin, strong facings (plastics, metal, wood, etc.) to a thick, lightweight core (foamed plastics, balsa wood, honeycombs, etc.) that separates and stabilizes the thin facings, thus giving them much greater stiffness.

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This *Primer of Plastics* touches only on the highlights of the industry. For complete discussions of specific phases, consult the Subject Index, p. 6.

Overseas developments

In common with the United States, overseas developments in processing, materials, and applications have come at a fast and furious pace within the past twelve months. The concise survey that follows, prepared by leading foreign experts in the plastics field, touches on some of these developments of world-wide interest.

FRANCE

By George Fabre*

Application of plastics in France during 1958 showed most progress in the fields of thermoplastics resins and reinforced plastics materials.

High-impact styrene, for example, turned up in several very large injection molded pieces—especially in refrigerator components. One refrigerator inner door, for example, stands 47 in. high; the interior, measuring 44 by 21 by 16⅓ in., is one of the largest injection molded pieces in existence.

Vinyl, which reached a production figure of 70,000 tons in 1958, also figures prominently in several French developments. Rigid vinyl ducts, for example, are being used in metal processing plants for evacuation of corrosive fumes; plasticized vinyl is being used for molding shoes and sandals; and heat-sealed PVC sheets have been adapted for protective packaging applications and for inflatables.

Nylon is also making continued progress in France. Many applications have developed in which molded bars and blanks of nylon are machined to shape in plants equipped with conventional metal-working tools. One of the largest manufacturers of cutlery in the country has started to use molded nylon handles. Blow molded hollow nylon shapes have also shown up in several applications and the canning industry has started to use thin, sterilizable nylon sheets that can be sealed together.

In the field of fibrous glass-reinforced polyesters, corrugated panels for roofing and decorative purposes still hold first place. But the material is now also beginning to appear in several large applications for the transportation industries. One-piece molded noses for electric motor carriages have been built for the French Railways and Régie Renault recently completed a scenic autorail car in which the center box frame, the entire air conditioning system, the inner stairway ramps, and the fuel tanks were among the many elements molded of reinforced plastics. Components for refrigerator cars and other commercial vehicles are also very much in demand.

Cast polyester has also started to move extensively into the optical field for spectacle and other lenses.

Processing developments

As in other European countries, much progress has been made with injection molding machines using screw-type pre-plastication. One French machine recently placed on the market has an original pre-plasticating device which uses a hollow injection piston. In another machinery development, a new type of valve has been developed for use in the injection molding of nylon. This particular unit operated successfully at the Lyons Fair for 10 days, molding more than 800 pieces a day without stopping. Also on the French market is a new injection machine with a flat rectangular piston and cylinder that is said to reduce the overheating of hard resins, such as rigid PVC. And, finally, mention should be made of the new French injection-extrusion machines that feed the material into molds on a rotating table.

In extrusion, one new development involves a process for impregnating fabrics to be used for conveyor belting, pipes, etc. A new engineering firm in France also recently introduced a line of machines that can extrude vinyl at rates ranging from 13 kg./hr. with a 30 mm. screw to 1350 kg./hr. with a 250 mm. screw.

Production figures

Production of plastics materials in France in 1958 reached almost 200,000 tons. Taking into account both imports and exports, French consumption of plastics amounted to more than 225,000 tons or about 5 kg. per person.

Among specific materials, vinyl is in first place, accounting for about ⅓ of all production. Polystyrene is second with polyethylene coming up strong. Polyester production is still low—only 6000 tons—but is increasing rapidly. The flourine-containing resins are only now first coming on stream in France, but much is expected of them in the future.

ITALY

By Dr. Ing. Giovanni Moretti*

The plastics industry in Italy in 1958, with a 23% increase in production (from 134,000 tons to 165,000 tons) and a 14% increase in consumption (from 128,000 tons to 146,000 tons), had a remarkably good year. It is interesting to note that a good share of the production (about 42%) is exported from Italy. Leading items among the exports in 1958 were artificial flowers, molded of polyethylene, housewares, buttons, and films and semi-finished articles of vinyl.

Recent applications

Many of the latest application developments in Italy have centered around rigid PVC materials. Now being produced are tubes up to 22 in. in diameter, molded valves up to 3 in., and flat sheets over 60 in. wide for lining industrial containers.

Considerable interest has been aroused recently in the possibilities for rigid vinyl sheets (corrugated or flat) in the building industry for roofing or wall lining. For such applications, a machine has been developed which takes large-diameter tubing (extruded from a high-capacity extruder with a through-put of more than 200 kg. of rigid PVC/hr.), cuts it open, and flattens it into sheets which are then longitudinally corrugated or otherwise formed, finished, and cut to required sizes. The sheets can be used for skylights, roofing, etc., are fireproof, nonbreakable, allow the use of lightweight supporting structures, and can be supplied in transparent, translucent, or opaque colors.

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*Editor, "Industrie des Plastiques Modernes."

*Montecatini Societa Generale per L'Industria Mineraria e Chimica, Milan, Italy.

Another important new application area for rigid PVC is in window and door frames made of shapes extruded directly over metal reinforcement. These shapes are then cut to size, assembled, and welded together at the corners with a special machine.

Vinyl in the form of a plasticized sheet is also involved in a new type of sandwich-construction in which the sheets are laminated to either side of a wire cloth core. Although still experimental, the material has already been suggested for use as a facing for earthen dams. In this application, the sheets would be welded to each other and secured to a concrete under-bed with explosive rivets.

An unusual material for flooring purposes is a recently developed combination of polyester resin and marble. The polyester resin is cast on the rough floor to form a bed into which suitably shaped pieces of marble are laid. Thus, the resin is used in place of concrete to bind the pieces together. And, unlike concrete, there is little possibility of cracks or fissures developing. In addition, since the resin fills the joints between the marble pieces, colored polyester can be used to create unusual effects.

The applications described above are a fair sampling of Italian plastics advances during 1958. The biggest news of the year, however, centered around polypropylene and its uses in the form of molded products, film, or monofilaments.

Although production is still not up to demand, polypropylene has already proved itself in a number of fields, most notably that of housewares and sanitary articles (such as syringe cases, surgical bowls, and containers for medicines and foodstuffs) that can be sterilized without deformation or distortion. The many outstanding properties of the material, especially its higher heat distortion point, have also led to its use in electrical home appliances, radio and TV sets, air conditioners, lights for motor cars, etc. In the industrial field, outstanding applications include valves, pipe, fittings, pumps, and linings for tanks where corrosive fluids or high temperatures are involved.

ENGLAND

By Dr. V. E. Yarsley*

Although there was a drop in plastics production in Britain in 1958, it was not enough to jar the optimistic prediction that plastics production should reach 2 million tons per year by 1983.

The current trend in Britain follows the world pattern in accenting the thermoplastics, although the thermosets have still managed to hold their own. Particularly noticeable in this connection is the increased demand for cellulose acetate, which, in the form of triacetate, has made a remarkable come-back in the production of fibers and films.

Most of the current advances in plastics production have centered on petroleum-based chemicals which in 1957 were reported to have amounted to 326,000 tons, an increase of over 30% as compared with 1956. Several new plants for polyethylene are reported under construction which should bring capacity for this material up to 100,000 tons. Also recently announced was a 30,000 ton polyolefin plant which will turn out both polyethylene and polypropylene. In some quarters, the danger of over-production had been suggested, but the fact that the markets for these materials expanded at the rate of 25% per annum during the past few years has tended to allay such fears.

For the present, Britain is still looking to America and Germany for supplies of such new materials as the polycarbonates and formaldehyde polymers.

The use of polyesters and epoxies in the production of reinforced plastics products has increased considerably in recent months.

Thermoset materials lost some of their custom molding business when the British Port Office decided to switch in 1959 to acrylic for molding its hand microphone sets. The application also represented a turning point in markets for molded acrylic. Heretofore, in Britain, cast acrylic sheet had been the major use for methyl methacrylate. In recent years, however, molded acrylic, as the result of improved formulations, has started to move into new markets, first into lighting fixtures and now into the hand microphone sets.

Much progress has also been made in the production of special polymers. The PTFE resins are now being produced in quantity and are being used in both solid form for molded industrial parts and as emulsion coatings.

Special high softening polymers are also being produced to meet the exacting demands of the electronics industry and are further being made available in cast sheets and ultra-thin films. At the research level, particularly in meeting the demands of aircraft and guided missiles, polymers of high thermal resistance based on phosphorus, nitrogren, boron, and fluorine are being actively investigated.

There has also been considerable processing development in the fields of injection and extrusion. One manufacturer, for instance, is now producing a 200-oz. machine which can mold a 12-lb. refrigerator liner.

Finally, the use of plastics in combination with metals is showing new possibilities, particularly as a result of the success achieved by a new PVC-coated steel sheet.

• • •

Editor's Note: On June 17, 1959, in Olympia, London, the First International Plastics Exhibition and Convention opened its doors to reveal several developments which are worthy of further mention.

In the machinery end, great strides were apparent in the design and production of pre-plasticating machines, particularly the twin- and single-screw types, by British and German companies.

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*Director, Yarsley Research Laboratories, Ltd.

Machines on display in this area ranged from 5- and 6-oz. single-screw preplasticating machines up to a 200-oz. unit using the twin screw principle incorporated in a two-stage unit. This latter machine has a plasticating capacity of 420 lb. of polystyrene per hour.

Blow molding machines also received considerable attention, as they did at the recent S.P.I. show in Chicago. A number of different types of vacuum and drape forming machines were also exhibited. Most of these emphasized an ability to get deeper draws than were heretofore possible and one composite machine was shown which is basically a drape machine with a pneumatic- or hydraulic-assisted core. This unit has been successful in the forming of polycarbonate and polypropylene materials.

In common with materials trends in Europe today, there was emphasis at the British exposition on blow molded nylon bottles for aerosols; high-impact PVC for water pipe, guttering, and downspouts; various plastics foams; ABS materials; and alkyd molding compounds for use in miniaturized electrical components, armaments, missiles, etc. A recent British development is a PVC-nitrile blend used for cable sheathing, hose covering, and lining, and the molding and extrusion of mechanicals.

JAPAN

By Hideo Adachi*

Although the plastics industry in Japan has grown 288% during the past five years, 1958 showed the smallest percentage increase in that period—only 5 percent.

The production of urea, polyester, and phthalic resins showed considerable growth. Polycarbonate resins were produced in 1958 on a pilot-plant scale and are now entering full-scale production to meet demand for the material for insulating applications.

The year 1958 also saw the first Japanese production of polystyrene and polyethylene. The latter material will be used primarily for film and for injection molded products. During 1959, several new plants under construction will add a total of 30,000 tons a year to polyethylene capacity; by the end of 1959, total capacity is expected to reach about 50,000 tons a year.

Corrugated rigid PVC panels for construction purposes have been made for several years, but glass-reinforced polyester sheets have started to move into competition.

To date, most of the rigid vinyl sheets have been made by calendering. More recently, however, 1 to 5 mm. sheet has been produced by extrusion using a T-die. The T-die has also been used for turning out rigid vinyl corrugated panels.

Vinyl film, 0.02 to 0.04 mm. thick and without plasticizer, has been turned out by a blown film technique and is claimed to be clearer than that produced by other methods.

The demand for vinyl film for agricultural purposes has been increasing year by year and in 1958, consumption grew to a record 6000 tons.

Another Japanese development is the use of molded nylon gears in sewing machines. The quantity is still small, but expectations are high.

Technical processing developments showed up primarily in the vinyl field. Rigid vinyl pipe, with diameters as high as 14 in., is being produced on extruders with L/D ratios as high as 25:1.

Additional data on Japan*

Part of the reason for the slowdown in plastics production in Japan in 1958 may be ascribed to reduced demand for and overproduction of vinyl. Since the turn of the year, however, the situation seems to have stabilized and it is expected that vinyl will continue to occupy a predominant position in the domestic as well as the export market.

The new plants that are just coming on stream for polyethylene also make it appear that this material may someday figure in Japan's export picture. In addition, a plant is now going up to produce styrene monomer in Japan; heretofore, the styrene monomer has been imported and then processed into the polymer by Japanese companies.

Predominant among Japanese applications are vinyl sheets and piping, reinforced plastics for electrical and architectural products, and vinyl and polyethylene film for agricultural purposes.

INDIA

By A. H. Srikanta Aiyar*

During 1958, India faced a serious foreign exchange crisis as a result of which severe restrictions were imposed on imports of even industrial raw materials. Industries such as plastics, which were dependent on imported raw materials, consequently suffered.

Production of plastics goods in 1958 was pegged down at the 1956 level. The latest import policy, however, has somewhat eased the situation in view of larger provisions for raw materials and more liberalization of imports.

Today, the plastics industry has over 150 units in the organized segment of the industry and innumerable small ones operated on a cottage-industry basis. The capital invested in the industry runs to more than 160 million rupees, providing employment to nearly 20 thousand workers.

During 1951 through 1956, the industry switched over to more diversified manufacturing, extending their sphere of activities from consumer items to such industrial applications as electrical accessories, telephone receiving sets, insulated cables, containers, etc. Now, the industry is concentrating on a tenfold expansion of plastics production with a target of 13,000 tons by 1961. To this end, several new plants went on stream during the 1957-1959 period.

A polystyrene plant went into production in May, 1957. During 1958, production of polystyrene powder amounted to 1906 tons, the capacity of the plant being 6 million pounds. The same firm also installed equipment for extrusion of high-impact styrene sheeting.

Production of urea formaldehyde molding powder began in early 1958. The capacity of the plant is 500 tons a year. Another urea plant, with a capacity of 400 tons per year, is expected to go into production before the end of 1959.

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*Director, Industrial Chemical Consultants, Inc., Tokyo, Japan.

*Supplied by H. Odimi, Japan Plastics Industry Assoc., Tokyo, Japan.

*Sec., The All India Plastics Mfrs. Assoc., Bombay, India.

During 1958, two calendering plants for making unsupported PVC sheeting and film went on stream, with an annual rated capacity of about 1200 tons on a single shift basis.

Two projects have been licensed by the Government for the manufacture of polyethylene molding powder using indigenous alcohol as the raw material.

On May 2, 1959, a polyethylene plant (using the high-pressure technique), with an annual capacity of 3500 tons a year to start, went on stream and another is expected to be ready in 1960.

A plant for making PVC from calcium carbide has been sanctioned and a plant with an initial capacity of 5 million lb. a year is expected to be ready either in 1960 or 1961.

A plant for the manufacture of nylon monofilaments has also been set up.

A small beginning has been made in India for the manufacture of small-capacity injection, compression, and extrusion machines.

The biggest injection machine in the country is of 32-oz. capacity and is being used for making 2½ to 3 gal. buckets and toilet seats from high-impact styrene.

Rigid PVC sheets are also now made in India in thicknesses of 1/16, 1/8, and 3/32 in., and in a wide range of colors. The largest molded item made of polyethylene is a 4-gal. capacity carboy.

GERMANY

By Dr.-Ing. Karl Mienes*

In the past year, production by the German plastics industry showed an increase of about 11.5% and reached 643,000 tons; this is about 16% of world production, which was around 4 million tons in 1958.

The greatest increase in volume was shown by polymerization products from copolymers, polyolefins, and acrylic resins. By the end of this decade, however, statistics will be more strongly influenced by some of the newer plastics materials and some of the newer production methods being devised to handle them.

Examples of such developments are inner liners for refrigerators of high-impact polystyrene and housings for domestic appliances of high melt viscosity polyamide which can be produced more successfully on screw-type injection molding machines than is possible by conventional methods. The development of a return flow "valve" has accelerated acceptance of these machines. This valve is a device which may be compared with a travelling torpedo that exerts a piston-like pressure, and is especially useful, when combined with screw plastication, for processing polymers with a high melt viscosity.

Other developments in materials and machinery in Germany which should be noted include:

High-density polyethylene and polypropylene now account for about ⅓ of the total production of polyolefins. A further increase in the production of both high- and lower-density polyethylenes will take place in coming years.

Thin-walled containers, from 2 to 20 gal. in capacity, have, for some time, been successfully blown from branched polyethylene.

There is an increasing tendency to use mechanically or electronically controlled automation in modern processing plants.

In the case of PVC, polyblends with better aging resistance have been developed with chlorinated polyolefins or polyolefin copolymers which supplement the nonrigid variations with elastomeric types.

The molding of large modified PVC structures, such as inner containers of refrigerators, by a combined deep drawing process has been done successfully in Germany for some time past. However, it is difficult to predict which material—high-impact polystyrene or modified PVC—and which process—the highly developed deep drawing technique or modern injection molding—will take the lead.

There is also a pronounced tendency to use time-saving devices and to arrange for simultaneous processing instead of successive operations. Examples of this tendency are found in automatic revolving extruding machines and transfer presses controlled in series and having a central extruder feed.

The latest developments aim at performing the plasticating and forming steps in separate but overlapping operations.

Processing techniques for elastomeric materials have slowly been improved. A typical example is the procedure used for urethane foam with the highly developed one-shot system. By means of continuously formed paper molds, which are automatically removed after solidification, an hourly output of 120 cu. meters is obtained. These devices also permit the processing of prepolymers of polyethers.

Considerable progress has also been made in foamed-in-place methods. Portable foaming devices operate in accordance with the counterflow injection principle. Typical applications are doors for vehicles, with outer skins of 0.8 mm. aluminum sheet between which the reactive mixture is foamed.

Expandable polystyrene foams are produced in Germany in the presence of low-boiling hydrocarbons in the polymerization process. In the meantime, the technique of using the expandable granulate in continuously operating mixing heads has advanced to a point where it compares with the production of blocks having a content of 1 cu. meter and a surface of 3 sq. meters. Such blocks are moved by their own weight through a system of parallel hot-wire cutters to produce slabs, sheets, and profiles.

In urethane elastomers, where a slightly cross-linked prepolymer is used, the casting and centrifugal technique for shaped articles such as gears or sheets is of primary importance. When casting or pouring cannot be used, as in the case of profiles and tubes, the process starts from high-molecular-weight isocyanates which are processed and cross-linked with polyesters in the same manner as conventional rubbers.

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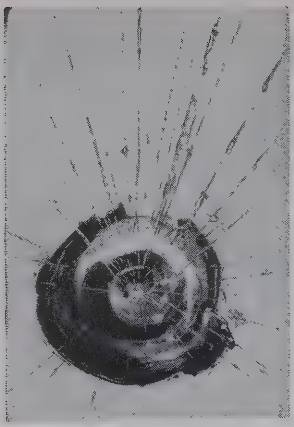
*Plastics Consultant, Bad Godesberg, W. Germany.



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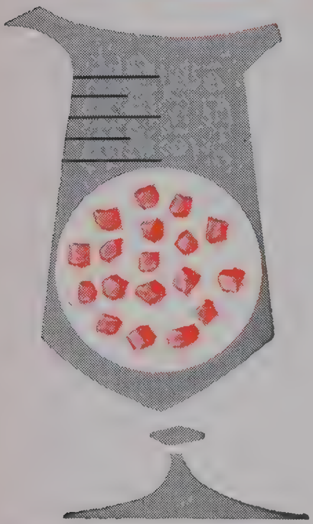

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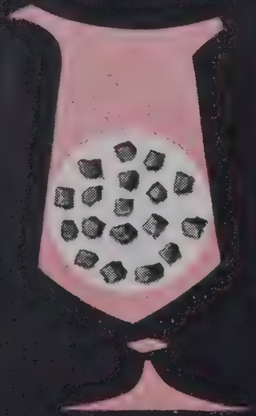

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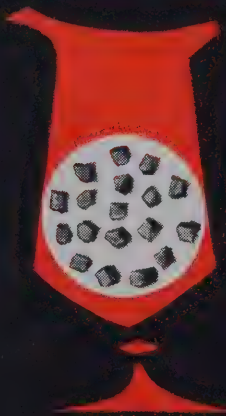

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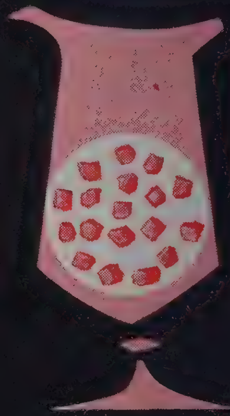

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PROPERTY	TYPE OF RESIN				TEST METHOD
MECHANICAL	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Tensile Strength[2] psi 160°F	3,300	3,300	4,500	5,500	D638-58T
73°F	5,100	5,100	6,400	7,800	
−40°F	7,800	7,800	9,400	11,500	
Tensile Modulus[2], psi 73°F	200,000	210,000	280,000	340,000	D638-58T
Flexural Strength[1] 160°F, 73°F, −40°F	No failure	No failure	No failure	No failure	D790-58T
Flexural Yield Strength[1], psi 160°F	4,300	4,100	5,900	6,800	
73°F	6,800	6,800	9,400	10,800	D790-58T
−40°F	10,500	10,500	13,800	16,000	
Flexural Modulus[1], psi 160°F	160,000	170,000	230,000	270,000	D790-58T
73°F	210,000	220,000	280,000	340,000	
−40°F	250,000	250,000	320,000	400,000	
Hardness[1]	R86	R87	R101	R108	Rockwell
			M10	M35	D785-51
Specific Gravity[1]	1.02	1.02	1.04	1.06	–
IMPACT STRENGTH	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Impact Strength[2], (Izod specimens, ft.-lb.)	⅛" bar	⅛" bar	⅛" bar	⅛" bar	D256-56 Method A
Un-notched 73°F	38.0	34.0	30.0	29.0	
Notched 73°F	6-8	5-7	3-5	4-5	
−20°F	3.0	2.0	1.4	0.9	
−40°F	2.0	1.5	1.0	0.7	
Impact Strength[1], (Charpy specimens, ft.-lb.)	¼" bar	¼" bar	¼" bar	¼" bar	D256-56 Method B
Un-notched 73°F	>40	>40	26.5	>40	
Notched 73°F	6.2	4.9	3.4	3.4	
−20°F	3.2	2.3	1.6	1.3	
−40°F	2.7	2.0	1.5	1.0	
THERMAL	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Heat Distortion Point[1], °F, 264 psi	196	196	198	215	D648-56
½"x½"x5" bar 66 psi	208	208	212	227	
(unannealed) Zero Load	223	220	220	238	
Heat Distortion Point[1], °F, 264 psi	224	220	219	232	
½"x½"x5" bar 66 psi	230	225	224	236	
(annealed) Zero Load	241	231	229	244	
Coefficient of Linear Thermal Expansion[1], in/in/°C	10.1x10^{-5}	10.4x10^{-5}	8.9x10^{-5}	7.8x10^{-5}	D696-44
Thermal Conductivity[1]					C177-45
Btu/hr/ft^2/°F/in	1.46	1.46	1.54	1.80	
Cal/sec/cm^2/°C/cm	5.05x10^{-4}	5.05x10^{-4}	5.30x10^{-4}	6.20x10^{-4}	
Flammability[1], in/min.	3.47	3.47	3.53	2.75	D635-56T
Deformation under load[1], % 24 hr/122°F/2000 psi	1.35	1.38	0.81	0.41	D621-51
Mold Shrinkage[2], %	0.5	0.5	0.5	0.5	D955-51
ELECTRICAL	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Dielectric Constant[1]					D150-54T
60 cycles	2.86	2.87	2.91	3.24	
10^3 cycles	2.85	2.86	2.91	3.21	
10^6 cycles	2.77	2.76	2.44	3.11	
Power Factor[1]					
60 cycles	.005	.005	.005	.005	D150-54T
10^3 cycles	.006	.006	.006	.006	
10^6 cycles	.008	.009	.008	.012	
Volume Resistivity[1], ohm-cm	>3.92x10^{16}	>3.80x10^{16}	>3.96x10^{16}	>3.57x10^{16}	D257-58
Arc Resistance[1], Sec	71	71	82	87	D495-58T

* [1] Compression Molded
[2] Injection Molded

The results given are based upon tests which we believe to be reliable. Due to varying conditions and methods of processing, we cannot guarantee results to be obtained. Nothing contained in this brochure is intended as a recommendation to use our products so as to infringe on any patents.

From bathtubs to boats . . . wherever a reinforced plastic surface must be smooth . . .

GLIDPOL GEL-KOTE suppresses fiber pattern with a continuous colored surface that needs no finishing!

GLIDPOL GEL-KOTES are pigmented polyester resin systems that give reinforced plastic products smooth, porcelain-like surfaces with excellent resistance to abrasion and cracking. GEL-KOTES withstand sunlight and weathering. After 12 months exposure in rugged Tide Range tests off the Florida coast, panels surfaced with GEL-KOTE showed virtually no change!

GLIDPOL GEL-KOTE can be sprayed or brushed on cold or hot mold surfaces prior to molding or laminating. This pigmented layer bonds to the molding resin to become an integral part of the molded product. No subsequent finishing operations are required.

GLIDPOL GEL-KOTES are formulated in 16 standard colors—from attractive new pastels to deep tones—plus black, white and translucent. Or, if you should require special colors, additional custom-formulated color systems can be provided. Write on your letterhead for complete details.

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U.S.I. POLYETHYLENE NEWS

A series for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

U.S. Industrial Chemicals Co., Division of National Distillers and Chemical Corporation 99 Park Ave., N. Y. 16, N. Y.

Packaging Notes

New research study on packaging has been issued by the American Management Association in book form. The book offers a comprehensive inventory of literature on packaging research. Current trends in packaging research, materials and methods are described. The book also lists principal sources of packaging information, such as periodicals, directories and manuals. The study includes a survey of packaging research needs and the special requirements of particular industry groups. The book is available for $6.00 from the AMA., 1515 Broadway, New York 36, N. Y.

Polyethylene bags for heavy transformers are saving an electrical equipment manufacturer $33,000 annually in packaging material costs. The company is shipping transformers ranging in weight from 300 to 1800 pounds in gusseted, 4-mil polyethylene tubing bags.

The transformers are readied for shipment by mounting them on prefabricated wooden skids, placing pieces of single-wall corrugated over the tops to protect the finish. The polyethylene bags are then placed over the transformers.

Previously, the company shipped its transformers in heavy paper covers and wooden crates. The new bags have resulted in substantial savings in labor costs and shipping weight. Hidden damage during shipment has also been reduced.

New machine does four color printing on plastic bottles. The machine accommodates one to four colors, does its printing by offset. The machine operates without mandrels, uses compressed air to print the plastic bottles. The unit employs two large conveyors and twin chains holding 14 bottles on slides.

Expanding carton with polyethylene liner is being tested by the Army as a means of serving hot rations to troops in the field. The carton, which holds dehydrated rations, has uncut, pleated top flaps which increase the carton's volume by a third when open. A polyethylene liner is unfolded and placed in the carton, hot water is poured into the liner and the dehydrated rations are placed in the liner and reconstituted. The increased size of the opened carton easily holds the extra volume of the reconstituted rations. The liner and carton form a leakproof mixing and serving container.

The new carton is expected to have civilian retail applications for powdered food products requiring the addition of liquid. These might include such mix-and-serve products as fruit drinks, milk, cocoa, gelatin desserts, pudding, hot cereals and instant coffee.

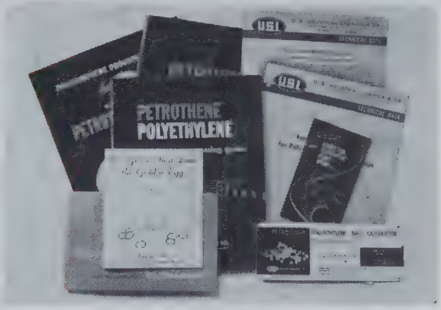
U.S.I. Offers New Literature For Polyethylene Processors, Packagers

Data on Film, Pipe, Molded Housewares, New Commercial Standards

Valuable information on polyethylene processing and packaging is now available from U.S.I. in the form of free booklets, processing tips and reference data. The information is based upon U.S.I.'s extensive polyethylene research conducted at the company's Polymer Research Laboratory in Tuscola, Ill. and from industry-wide marketing and packaging studies.

Among the literature offered is:

PETROTHENE ***Polyethylene — A Processing Guide*** — A 96-page booklet discussing technique for processing polyethylene, processing problems, and polyethylene properties.



Formulas and Tables for Polyethylene Film and Bags for determining such factors as feet of film of various gauges from a given quantity of resin; weight per 1,000 feet of film, or number of bags of a given size that can be made from a quantity of polyethylene film. The tables are particularly useful to film extruders and those who make or use polyethylene film bags.

Slide rules with the same type information are also available.

Which Polyethylene Film Should I Use, which relates to the new Recommended Commercial Standard for Polyethylene Film (TS-5438) and indexes the various types and gauges of polyethylene film recommended for different packaging jobs. The corresponding PETROTHENE resins for each type film are also listed for easy reference by extruders.

Other literature offered includes a booklet on polyethylene pipe standards, "How to Choose and Use Polyethylene Plastic Pipe," "The Goose That Laid The Golden Egg," U.S.I.'s famous guide for buying polyethylene housewares; a complete collection of the well-known "Processing Tips" which U.S.I. has published regularly in leading plastics publications; and the booklet "Polyethylene Creates New Opportunities in Packaging."

To order any of this material, write to Editor, U.S.I. Polyethylene News, U. S. Industrial Chemicals Co., 99 Park Avenue, New York 16, N. Y.

Poly-Coated Pipe Resists Underground Corrosion

The first steel pipe in the industry to be coated with an extruded plastic is finding widespread use by gas, oil and chemical companies with underground pipeline installations.

The pipe is factory coated with extruded polyethylene applied over an elastic adhesive undercoating. The coating has high insulation resistance and dielectric strength. This is especially important in underground pipelines where stray ground currents are a troublesome cause of pipe corrosion. The plastic coating is so tough and resilient that rocks can be bounced off the pipe without piercing the coating. The pipe can be bent in the field without damage to the coating.

Polyethylene Film "Bubble" Speeds Construction Work

A "warm air bubble" of polyethylene film inflated over excavation site thaws the area sufficiently for concrete to be poured even in subfreezing winter weather.

This novel application of polyethylene film has been used successfully by several construction companies. In one operation a 50 x 64 foot sheet of film was anchored to the ground with cement building blocks and inflated with warm air from the blower of a temporary furnace. About two pounds per square inch pressure was used. Concrete was then poured in temperatures that ranged down to zero. The bubble was left up for three days to give the concrete time to cure without freezing.

New U.S.I. Plant Reaches Full Output In 6 Weeks

U.S.I.'s new 75 million pound polyethylene plant at Houston, Texas, reached capacity production just six weeks after going on stream.

Production reports show that quality of the material produced is high. A sizeable proportion of the output to date has been film grade and coating resins. Plans are already underway to double the capacity of the Houston plant by the third quarter of 1960.

2-mil cast polyethylene film made from PETROTHENE 239-27 resin has unprecedented clarity and gloss.
CAST PETROTHENE®
POLYETHYLENE
CIGARS
new...
clear
inexpensive

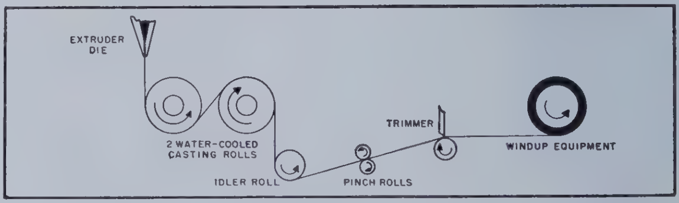
CAST POLY FILM PACKAGES IT BETTER...FOR LESS!

In a single year cast polyethylene film has become a major packaging material. Frozen food, produce, bread, hosiery, sheets, towels, paper plates . . . even tortillas and tamales are now packaged in clear, tough cast poly film. Here's why you offer your customers a better packaging material for their money when you offer them cast polyethylene film:

CRYSTAL CLARITY — PETROTHENE® cast poly film has an appearance equal to or better than that of other commonly used transparent packaging films. What's more it has a soft, natural flexibility that adds a look of quality to packaged goods.

SUPERIOR PACKAGING PROPERTIES — PETROTHENE cast film has good impact and tear strength, high grease resistance and is an excellent moisture barrier. It heat seals well and is easily printed. Cast film handles well in overwrap machinery designed for conventional polyethylene film.

ECONOMY — Your customers will pay less for cast poly film than for other highly transparent flexible packaging materials—whether they figure costs per pound or per unit area of film. It is the most inexpensive high-clarity overwrap material your customers can buy.



Cast polyethylene film is made by a special process employing U.S.I. PETROTHENE resins. U.S.I. will be glad to furnish technical assistance to extruders interested in manufacturing cast poly film. Contact your nearest U.S.I. office, or write:

U.S.INDUSTRIAL CHEMICALS CO.
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99 Park Avenue, New York 16, N. Y.
Branches in principal cities

exceptional moisture and grease resistance

POLYETHYLENE-COATED KRAFT OPENS UP NEW OPPORTUNITIES FOR CORRUGATED BOARD

Polyethylene-coated corrugated board — produced on conventional corrugating equipment — is extending the usefulness of corrugated into many new packaging applications.

This unique container board has exceptional moisture and grease resistance and a glossy, non-abrasive liner surface that will not scratch or mar package contents.

Extruders who produce polyethylene-coated kraft liner board can get these extra advantages by using U.S.I. PETROTHENE® polyethylene resins:

HIGH PRODUCTION RATES—PETROTHENE resins have good drawdown properties, permit extrusion at high speeds.

EXCELLENT ADHESION — with minimum hot melt oxidation.

NO ODOR — an important consideration in many packaging applications.

Contact U.S.I. for information on PETROTHENE resins especially suited for coating kraft liner board.

Packagers are investigating polyethylene-coated corrugated board for applications like these:

Bulk shipment of meat, where moisture and grease-proof interiors reduce weight loss of the meat and keep moisture from weakening the carton.

Shipment of furniture and other hard goods, where abrasion damage from the container has been a problem.

Bulk bakery and confectionery shipments, where absence of grease-wickage makes containers suitable for reuse as point-of-sale displays.

In concrete construction forms, where the polyethylene coating acts as a release agent.

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GUIDE TO PETROTHENE POLYETHYLENE RESINS

RESINS SUGGESTED FOR FILM EXTRUSION

	APPLICATION	GAUGE (MIL)	ESSENTIAL PROPERTIES	SUGGESTED PETROTHENE RE
BLOWN FILM	Garment bags	0.4 to 0.75	Excellent draw-down, excellent clarity, high gloss, resistance to blocking, good slip.	207, 239
	Soft-goods bags	0.75 to 1.25	High draw-down, high clarity, good gloss, resistance to blocking, good slip, fair toughness	206, 207
	Produce bags small	1 to 1.25	Moderate toughness, clarity, gloss, resistance to blocking, good slip	205, 210
	large	1.5 to 2	High toughness, fair clarity, gloss, resistance to blocking, good slip	200, 205, 21
	Chemical packaging bags (drum liners)	1.5 to 3	Very high toughness, resistance to blocking, good slip	200, 204
	Construction	4 to 6	Extreme toughness	200, 301
FLAT FILM	Soft-goods bags and Overwrap	0.75 to 2	High draw-down, clarity, gloss, resistance to blocking, good slip	239
	Bread wrap	1	Excellent clarity, gloss, stiffness	239
	Produce bags	1 to 2	Moderate to high toughness, clarity, resistance to blocking, good slip	200, 205, 21
	Construction	4 to 6	Extreme toughness	200
AGRICULTURAL FILM	Mulch	0.75 to 6	Moderate toughness, high draw-down	201-210

RESINS SUGGESTED FOR OTHER APPLICATIONS

USE	ESSENTIAL PROPERTIES	SUGGESTED PETROTHENE RES
PAPER COATING	Good draw-down, freedom from odor, good adhesion, grease proofness, heat sealability	
	Best draw-down	203, 207, 239
	Highest resistance to permeability	239
	Minimum "neck-in"	100, 200, 205
	Balanced properties	205, 210
WIRE AND CABLE COATING	Excellent dielectric properties	
	Excellent resistance to environmental stress cracking	
	High frequency insulation, power cables	300-6
	Wire and cable jackets, where unusual stress crack conditions are encountered	300-200
	Primary insulation for telephone cables, general insulation where color coding is required	300-Color Code
	Good resistance to environmental stress cracking	
	High frequency coaxial cables; primary insulation for telephone cables, multi-conductor control cables, power cables	301-6
	Weather resistant wire and cable; neutral supported secondary and service drop cable	301-200
	WD-1/TT Infantry field wire	301-202
	Primary insulation for telephone cables; general insulation where color coding is required	301-Color Code
	General-purpose applications	
	Non-critical, non-specification insulation	302-6
	TV antenna lead-in wire	302-506
INJECTION MOLDING	Fast flow, maximum stiffness	
	Size:	
	Very large (>20 oz)	208
	Very large (>20 oz), high resistance to low-temperature brittleness and shattering	202
	Large (10 to 20 oz)	202, 203, 207, 208
	Small (6 to 10 oz)	201, 203, 206, 207, 239
	Very small (<6 oz)	200, 204, 205
	Best transparency and gloss	207, 208
	Best freedom from warp (low level of locked-in stresses)	202
BOTTLE BLOWING	Best appearance	102, 201, 206
	Highest environmental stress cracking resistance	102, 301
THERMOFORMING	Stiffness, chemical resistance, low water absorption	205, 239
	Maximum resistance to sag	239, 301
	High stiffness and thin walls	239
	Optimum toughness and great flexibility	301
	Good balance of end properties	205
PIPE EXTRUSION	NSF approved for potable water	102-216
	Nonpotable water supplies	550-218
CALENDERING		102, 102-216

FORM: Solid cubes approximately ⅛″ on a side.
COLOR: All PETROTHENE types are available in various colors as well as natural.
PACKAGING: Polyethylene coated multi-wall bags — net weight 50 lbs.: 1500 lbs. and 9000 lbs. U. S. Rubber Sealdbins. Palletized shipments upon request.
MINIMUM ORDER: 50 lbs.
TERMS: Net 30 days.
AVAILABILITY: Warehouse stocks are maintained in most major processing areas. Your nearest U. S. I. Sales Office will give you detailed information on delivery dates.
TECHNICAL SERVICE: For technical assistance contact your nearest U. S. I. Sales Office.

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BESTWALL

Industrial Gypsum Plasters

for pattern and mold work *(low expansion Densites)*

POURING PLASTERS

	Strength	Plasticity	Expansion
K-12	highest	minimum	lowest
K-17	high	medium	low
K-31	high	minimum	low
K-34	maximum	none	higher

Characteristics & Uses

For pattern and model work where great strength, hardness and wear resistance are desirable in a low expansion material. Minimum amount of plasticity.

Ideal where accurate dimensions must be maintained.

For pouring solid models and patterns.

Extreme surface hardness. Viscous pouring properties.

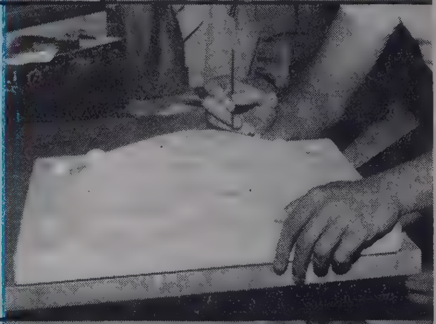
PATTERN MAKING PLASTERS

	Strength	Plasticity	Expansion
K-25	high	high	low
K-32	medium high	high	high
K-36	medium high	highest	highest
K-33	highest	medium	medium

Characteristics & Uses

For pattern and model work where highest degree of plasticity is desirable.

Specifically designed for splash casting, built-up work and rodding to contour.

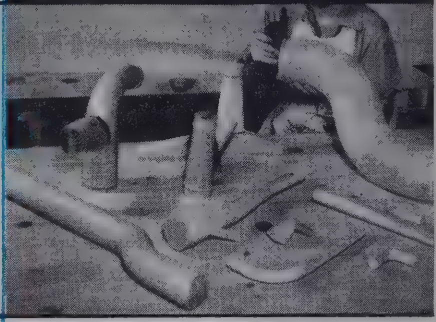


BREAKAWAY PLASTERS

This is a special gypsum plaster of high water carrying capacity and relatively low strength.

Used for expendable mandrels that can be readily broken up and removed.

To remove plaster, the set cast can be disintegrated with hot water or steam.



Bestwall also makes a line of Sunflower Molding Plasters with medium and low expansion qualities. Complete information on these and all Bestwall Industrial Plasters is available from your Bestwall representative. He will be happy to help you with any molding and patternmaking problem, including the development of special formulas to meet specific needs.

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BESTWALL GYPSUM COMPANY • Ardmore, Pennsylvania • Plants and offices throughout the United States

plastics and resins

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FIRE-RESISTANT UREA
WOOD-FLOUR FILLED UREA
NYLON
ALKYD
POLYESTER
URETHANE FOAM
PHENOLICS
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Plaskon

Urea Molding Compound

PLASKON Urea Molding Compound is available in an unlimited range of colors ranging from pure white through the pastels to brilliant hues. Products molded of PLASKON Urea resist chipping and cracking and are tasteless, odorless and inert. It is highly resistant to grease, oil and common solvents, and possesses high dielectric strength and arc resistance. The material is heat resistant and has excellent dimensional stability.

Applications include closures, wiring devices, stove and cabinet hardware, toilet seats, lighting fixtures, radio, appliance and other housings, cosmetic and jewelry containers and buttons. A housing type PLASKON Urea Molding Compound has been specifically developed for the fabrication of large parts and housings.

Melamine Molding Compound

Products molded of PLASKON Melamine Molding Compound possess the hardest surfaces found in plastics. PLASKON Melamine has all of the advantages of PLASKON Urea, but also offers a higher resistance to acids, alkalies and heat as well as lower moisture absorption. Varying degrees of translucency are possible to further enhance the beauty of the molded products with their unlimited color range and smooth, easy-to-clean surfaces. Applications include dinnerware, appliance housings, electrical parts and wiring devices, cutlery handles and buttons.

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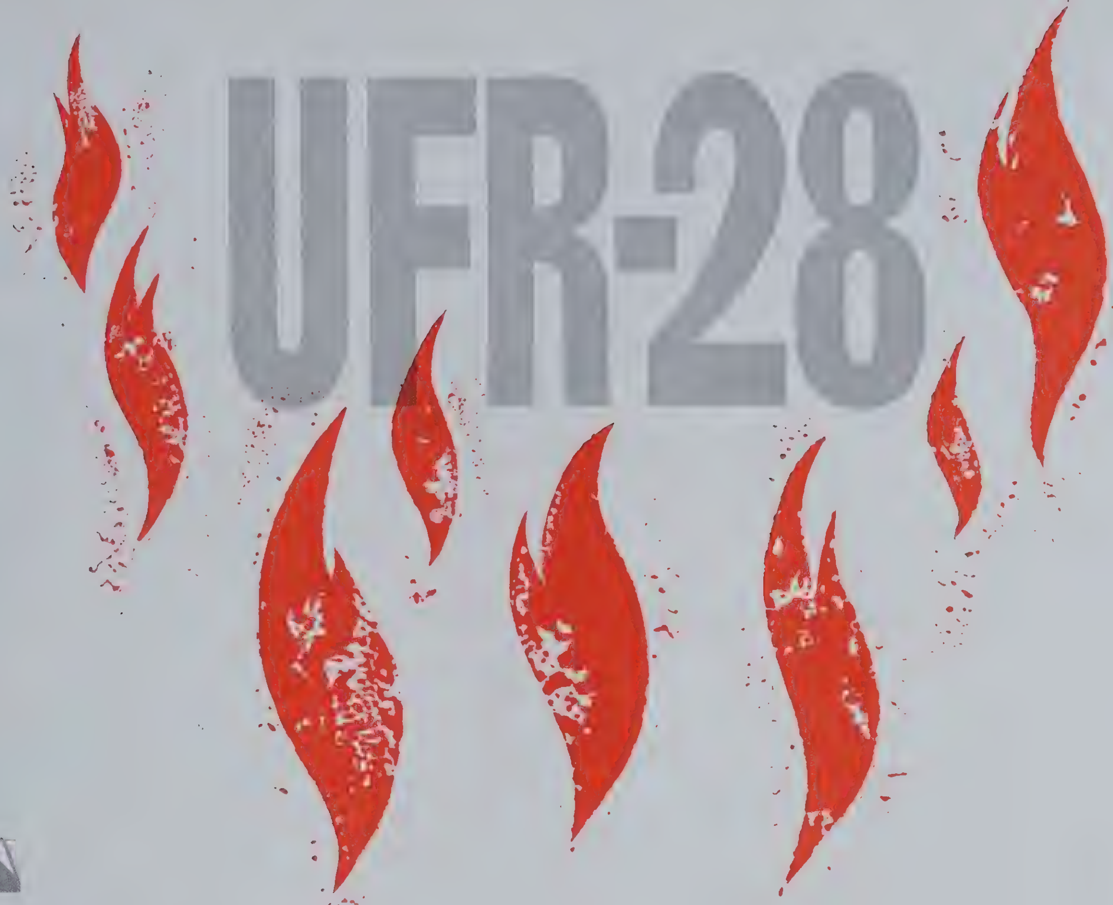

Plaskon

Fire-Resistant Urea

Fire-resistant type PLASKON Urea Molding Compound, UFR-28, was specifically developed to fill the lighting and appliance industries' need for a plastic material with a low flame spread rating, which could be readily molded. This new urea type, possessing an Underwriters' Laboratories flame spread rating of 25 to 75, provides the fire resistance required by municipal, state and national building codes.

In addition to possessing all of the qualities of standard PLASKON Urea, UFR-28's self-supporting rigidity facilitates its use in the new "luminescent ceiling" approach to lighting — providing the ultimate in lighting efficiency and beauty.

PLASKON Urea Molding Compound UFR-28 is supplied in an unpigmented natural color, with a range of tint shades also available.

Wood-Flour Filled Urea Molding Compound

Available in black, NEMA Brown and closure brown, PLASKON Wood-Flour Filled Urea is an improved general purpose molding compound which gives molded products excellent arc resistance and electrical insulation properties, hardness, lightfastness and inertness to chemical and pharmaceutical reagents. For many applications the wood-filled product is as satisfactory as the cellulose-filled type, the only substantial difference between the two being in the relative opacity and color quality. The material is tasteless and odorless and highly resistant to electrical tracking.

Applications include wiring devices, switch plates, closures and household and light industrial electric switchgear.

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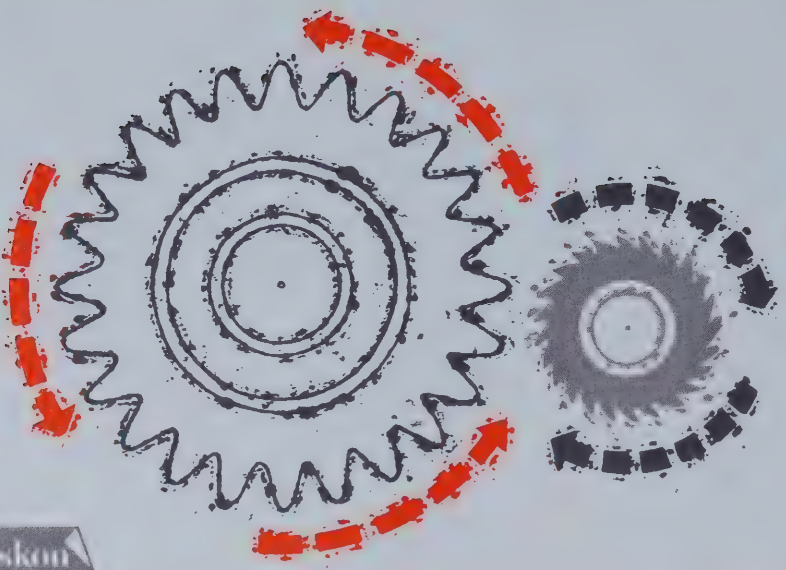


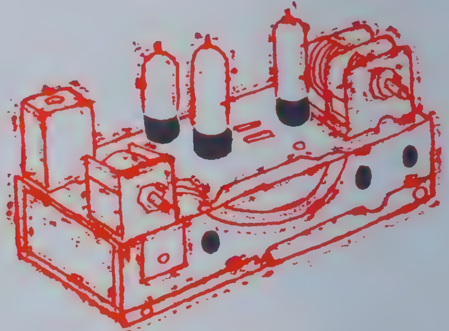
Plaskon

Nylon Molding and Extrusion Compounds

To meet specific requirements for a wide variety of applications, a number of specialized PLASKON Nylon Molding and Extrusion Compounds have been developed. Both the low viscosity (PLASKON 8200, 8201 and 8202) grades and the ultra high viscosity (PLASKON 8205) grade are widely accepted engineering materials with exceptional toughness, abrasion resistance, self-lubrication, high heat distortion temperature, high strength to weight ratio and good chemical resistance.

PLASKON Nylon provides less shrinkage and superior dimensional control for precision parts such as gears and bearings than other nylon types. It has a broader melting range and can be molded at lower temperatures and pressures. It also offers superior impact strength, better moldability in thick sections, and lends itself more readily to pigmentation.

Small diameter tubing, tape, and specialty packaging film, extruded from PLASKON Nylon Resin, are finding increasing prominence, due to the material's superior mechanical and chemical properties. Production of these specialized forms is possible because of the high melt viscosity of PLASKON Nylon.



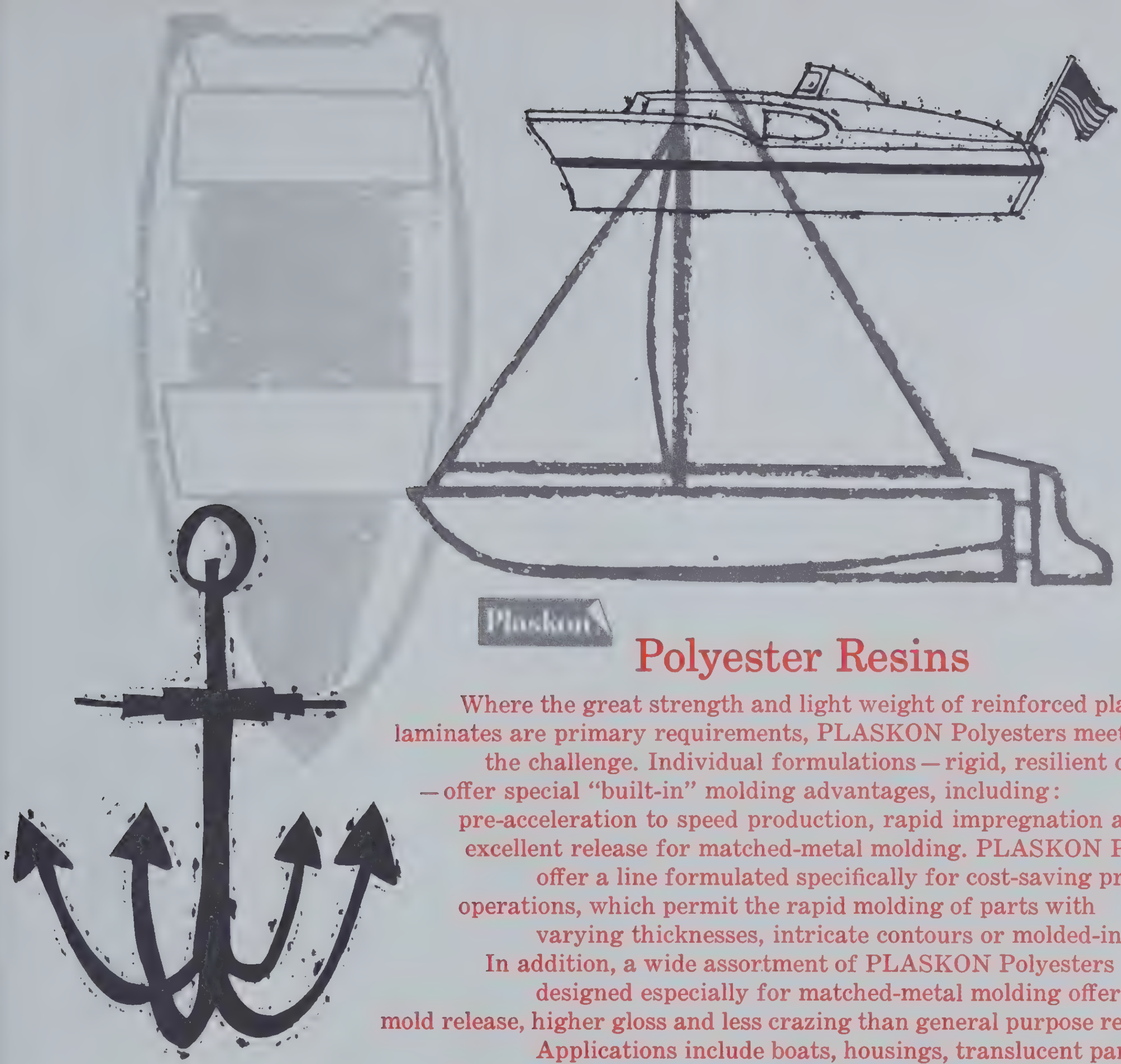
Alkyd Molding Compound

Parts molded from PLASKON Alkyd Molding Compounds meet the increasingly stringent demands of the electrical and electronics industries for reliable performance. They provide the high arc and insulation resistance and dielectric values required by designers and engineers, for applications at elevated temperatures or exposure to heat and humidity. The have unusually high dimensional stability. This, and the fact that they are adaptable to rapid production cycles permits endless reproduction of high tolerance precision parts.

Alkyd Granular materials are designed for high speed automatic or semi-automatic molding. Contacts may be molded-in or inserted in a separate operation. Uses include automotive ignition, motor controllers, vacuum tube bases and sockets, tuning devices, switch and relay parts.

Alkyd Putty is recommended for encapsulation of resistors, capacitors, coils, transformers — small electronic devices where delicate inserts are to be molded within a protective shell. The material molds rapidly at extremely low pressures.

Reinforced Alkyd materials contain glass fiber for increased mechanical strength. Characterized by superior electrical properties, it finds use in the molding of computer parts, synchros, coil forms, terminal blocks and heavy duty circuit breakers and switch gear.



Plaskon

Polyester Resins

Where the great strength and light weight of reinforced plastic laminates are primary requirements, PLASKON Polyesters meet the challenge. Individual formulations — rigid, resilient or flexible — offer special "built-in" molding advantages, including: pre-acceleration to speed production, rapid impregnation and excellent release for matched-metal molding. PLASKON Polyesters offer a line formulated specifically for cost-saving pre-mix operations, which permit the rapid molding of parts with varying thicknesses, intricate contours or molded-in inserts. In addition, a wide assortment of PLASKON Polyesters designed especially for matched-metal molding offer excellent mold release, higher gloss and less crazing than general purpose resins. Applications include boats, housings, translucent panels, furniture, packaging and aircraft components.

Urethane Foam

PLASKON Urethane Foaming Systems play a leading role in the booming market for polyurethane foams. Easy-to-handle, pre-mix rigid foams are available as well as a wide range of flexible foams. Special formulations offer predetermined properties such as heat resistance, compressive strength, or water resistance to meet the individual requirements of specific applications.

Foams produced from these systems offer extremely low K Factors, sound dampening and vibration deadening properties that make these materials well suited for a wide range of insulation applications. In flotation chambers, closed cell PLASKON Urethane Foams offer permanent high buoyancy, ease of foaming in place to completely fill irregular shaped voids, and maximum dimensional stability even when submerged in water. Applications for which this material is suited also include core materials for building panels, radomes, and load-bearing sandwich construction; and sprayed-on insulation.

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Phenolic Resins

PLASKON Phenolic Laminating Varnishes find wide use in the preparation of decorative and electrical grade laminates. Several new flame retardant laminating resins are available for the preparation of laminates for switchgear and printed circuit applications. A special resin has been developed for high-strength, glass or asbestos reinforced laminates for use in high temperature aircraft and missile parts. These laminates offer excellent retention of strength and stiffness at temperatures up to 700°F.

Liquid PLASKON Phenolic Resins are also available for the preparation of a wide range of industrial items such as thermal insulation, battery separators, oil and air filters and shell molds and cores for foundry work. A new pre-mix resin allows the preparation of reinforced phenolic molding materials with extensive application potential, using a pre-mix process similar to that used with polyester resins.

Coating Resins

PLASKON Coating Resins include a complete line of alkyd, urea, melamine, styrenated alkyd, silicone alkyd, modified phenolic, maleic and ester gum resins for use in the surface coating and printing ink industries. Each resin is designed to impart specific characteristics such as gloss, superior gloss retention, chemical and solvent resistance, durability or rapid drying for interior and exterior appliance, automotive and industrial applications. Precisely controlled and made from carefully selected top quality raw materials, PLASKON Coating Resins' reputation for reliable performance is supported by years of experience, progressive research and modern facilities.

Applications for these quality resins include paints, varnishes, lacquers, printing inks and self-polishing floor waxes.

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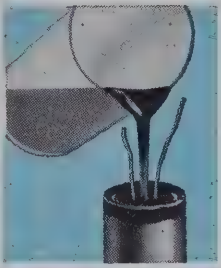
WHEN CATALOGING YOUR POLYESTER AND EPOXY NEEDS

CHECK RCI

for resins tailored to your requirements

PLASTIC TOOLING—EPOTUF epoxy resins and hardeners for compounders of plastic tooling materials.

At left — a light weight, low-cost plastic stretch die with excellent dimensional stability.



ENCAPSULATING—POLYLITE polyester resins and EPOTUF epoxy resins.

Electrical apparatus encased in EPOTUF resins is protected from insulation breakdown and assured of a long, trouble-free life.

MOLDING & LAMINATING—POLYLITE polyester resins and EPOTUF epoxy resins.

Illustrated at left is a durable yet attractive portable freezer display unit for food stores fabricated with POLYLITE resins and fibrous glass.

SURFACE COATINGS—POLYLITE polyester resins and EPOTUF epoxy resins.

EPOTUF resins produce superior protective coatings for interiors of metal containers and pipe used to carry corrosive chemicals.

POLYURETHANE FOAM PRODUCTION—Rigid foam formulations based on POLYLITE polyester resins.

In addition to heat and sound insulation a major application for this light weight, structurally stable material is its use as a "flotation medium" in boats like the one shown here, many of which also boast reinforced polyester hulls.

For complete information on how RCI polyester and epoxy resins can best serve your individual needs, clip and mail coupon.

☐ Plastic Tooling ☐ Molding & Laminating

☐ Surface Coatings ☐ Encapsulating

☐ Polyurethane Foam Production

Please send me full technical information on the use of RCI Polyester and/or Epoxy resins for the application indicated above.

Name____________________________

I am____________________________
(title)
of the company indicated on this letterhead.

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite
Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate
Sulfuric Acid • Methanol

REICHHOLD CHEMICALS, INC.,
RCI BUILDING, WHITE PLAINS, N. Y.

Creative Chemistry . . . Your Partner in Progress

RCI

REED PLASTICS CORPORATION

an independent processor of thermoplastics devoted to SERVICE!

REED SUPPLIES THESE SERVICES

- Custom compounding
- Standard colors
- Special colors
- Reprocessing

- OVERNIGHT SERVICE
  - Samples
  - Production
  - Color Matches
- SPECIAL EFFECTS
  - Pearlescents
  - Fluorescents
  - Phosphorescents
  - Metallics
- THERMOPLASTIC REPROCESSING
  - Grinding
  - Sorting
  - Sawing
  - Reclaiming
  - Recoloring

REED SUPPLIES THESE THERMOPLASTICS

- POLYSTYRENES
  - General Purpose Polystyrenes
  - Heat Resistant Polystyrenes
  - Medium Impact Polystyrenes
  - High Impact Polystyrenes
  - Extra High Impact Polystyrenes
  - Polymethylstyrenes
  - Acrylonitrile Styrene Copolymers
- POLYOLEFINS
  - Polyethylenes
  - Linear Polyethylenes
  - Polyethylene Blends
  - Polyethylene Copolymers
  - Polypropylenes
- CELLULOSICS
  - Cellulose Acetate
  - Cellulose Acetate Butyrate
  - Cellulose Propionate
- ACRYLICS
  - General Purpose
  - High Impact Acrylics
- NYLONS

REED SERVICES THESE INDUSTRIES

- Automotive
- Bottle & Closure
- Camera
- Comb and Brush
- Cosmetic
- Electronic
- Eyeglass
- Hardware
- Housewares
- Jewelry
- Packaging
- Plumbing
- Radio and Television
- Refrigeration
- Shoe
- Toy
- Wall Tile

REED SUPPLIES THESE COLOR CONCENTRATES

- Polystyrenes
- Polyethylenes
- Linear Polyethylenes
- Polypropylenes

REED SUPPLIES THESE SPECIAL COMPOUNDS

- Flame retardant compounds
- Ultra-violet stable compounds
- Expandable compounds

REED PLASTICS CORPORATION
116 gold street, worcester 8, mass.

Monsanto

PLASTICS FACT FILE

plastics
centered
for
industry

MONSANTO CHEMICAL COMPANY

LUSTREX

styrene

Monsanto Lustrex is one of the lightest and most widely used thermoplastic molding materials. Tasteless, odorless and non-toxic; with high dimensional stability, hardness, rigidity, and dielectric strength, Monsanto Lustrex can be molded to any sharply defined detail and finish. Molding compounds for compression and injection molding and extrusion in all types of machines and molds. Special formulations suitable for extrusion and vacuum forming. Available in a broad range of transparent, translucent, and opaque colors, as well as crystal.

special formulations for . . .

. . . general purpose applications:
 Lustrex Hi-Flow 55 (improved flow)
 Lustrex Hi-Flow 66 (long flow, moderate set-up)
 Lustrex Hi-Flow 77 (good flow, fast set-up)

. . . medium and high impact strength applications:
 Lustrex Hi-Test 42 (medium impact,
 Lustrex Hi-Test 48 high translucence)
 Lustrex Hi-Test 88 (high impact)

. . . heat resistance applications:
 Lustrex Hi-Heat 99 (up to 204°F.)
 Lustrex Hi-Test 89 (heat resistant, high impact)

. . . for applications requiring fluorescent light stability:
 general purpose formulations are available in Lustrex permatone

. . . for applications requiring dust resistance:
 both general purpose and impact formulations are available in Lustrex Lo-Stat

property	ASTM test method
mechanical	
tensile strength, psi	D638-56T
elongation at break, %	D638-56T
modulus of elasticity (in tension), psi	D638-56T
hardness, Rockwell "M" scale	D785-51
flexural strength, psi	D790-49T
deflection at break, in.	D790-49T
impact strength, notched izod, ½" x ½", ft. lbs./in. of notch	D256-56
thermal	
thermal expansion, in./in./°C	D696-44
heat distortion temp. compression molded, °F. at 264 psi fiber stress	D648-56
deformation under load	
% at 4000 psi and 50°C	D621-51
% at 2000 psi and 50°C	D621-51
optical	
light transmission at 550 millimicrons	D1003-52
(0.050" thick) % unpigmented specimen	
(0.100" thick) % unpigmented specimen	
color possibilities	
physical	
specific gravity	D792-50
moisture absorption, %	D570-57T
burning rate (0.050" thick), in./min.	D635-56T
electrical	
dissipation factor, 10^6 cycles/sec.	D150-54T
dielectric constant, 10^6 cycles/sec.	D150-54T
dielectric strength, volts/mil. ⅛" thick.	D149-55T
volume resistivity, ohm/cm.	D257-57T
molding	
bulk factor (pellets)	D954-50
injection molding temp., °F.	
injection molding pressure, psi	
mold shrinkage, in./in.	D955-51
ASTM material type	
specification D703-56T	

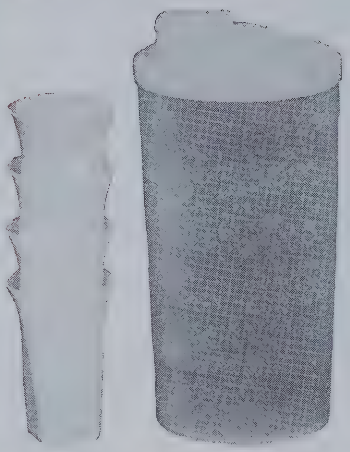
typical applications

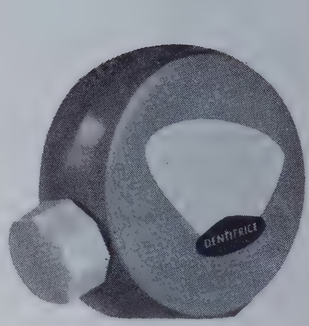
refrigerator parts
toys
packaging
air conditioner cabinets
radios
housewares
wall tile
television components
displays
electrical equipment
lighting fixtures
furniture drawers
phonograph records

rubber modified types					general purpose grades			
Hi-Test 42 medium impact	**Hi-Test 44 medium impact**	**Hi-Test 48 medium impact**	**Hi-Test 88 high impact**	**Hi-Test 89 high impact heat resistant**	**Hi-Flow 55 soft flow**	**Hi-Flow 66 medium flow**	**Hi-Flow 77 regular flow**	**Hi-Heat 99 heat resistant**
4800–5800	4500–5700	3800–4750	3500–4500	6500–7500	5500–6500	6300–7800	6500–8000	7400–8400
10–13	10–15	15–20	20–30	3–5	1.5–2.2	1.7–2.4	1.8–2.4	1.9–2.4
4.5–5.0x10^{5}	4.3–4.6x10^{5}	4.0–4.5x10^{5}	3.5–4.0x10^{5}	4–5x10^{5}	4–5x10^{5}	4–5x10^{5}	4–5x10^{5}	4–5x10^{5}
75–80	70–75	55–65	46–55	70–75	70–80	70–80	70–80	76–80
no failure	no failure	no failure	no failure	no failure	8000–12,000	8500–12,500	9000–13,000	11,000–14,000
>0.20 (yield)	>0.20 (yield)	>0.20 (yield)	>0.20 (yield)	>0.20 (yield)	0.15–0.35	0.18–0.35	0.15–0.35	0.15–0.35
0.40–0.45	0.45–0.50	0.60–0.65	0.70–0.80	0.70–0.80	0.25–0.35	0.25–0.35	0.25–0.35	0.25–0.35
7–8x10^{5}	7–8x10^{5}	7–8x10^{5}	7–8x10^{5}	7–8x10^{5}	6–8x10^{5}	6–8x10^{5}	6–8x10^{5}	6–8x10^{5}
165–175	165–175	163–173	166–176	194–198	165–172	176–183	183–191	196–201
0.9–1.3	1.0–1.5	———	not applicable	not applicable	2.6–2.8	1.5–1.7	0.8–1.0	0.8–1.0
———	———	1.1–1.5	1.5–2.0	0.5–0.8	———	———	———	———
86–88	85–87	80–85	70–75	64–66	88–90	88–90	88–90	88–90
83–85	80–85	65–70	60–65	41–43	88–90	88–90	88–90	88–90
translucents to opaques	translucents to opaques	translucents to opaques	translucents to opaques	translucents to opaques	unlimited	unlimited	unlimited	unlimited
1.05–1.07	1.05–1.07	1.05–1.07	1.05–1.08	1.05–1.08	1.04–1.06	1.04–1.06	1.04–1.06	1.04–1.06
0.03–0.07	0.03–0.07	0.03–0.07	0.07–0.08	0.07–0.08	0.03–0.04	0.03–0.04	0.03–0.04	0.03–0.04
1–2	1–2	1–2	1–2	1–2	1–1.5	1–1.5	1–1.5	1–1.5
.0002–.0004	.0002–.0004	.0002–.0004	.0003–.0005	.0009–.0010	.0001–.0005	.0001–.0005	.0001–.0005	.0001–.0005
2.50–2.60	2.50–2.60	2.52–2.65	2.55–2.70	2.55–2.70	2.52–2.65	2.52–2.65	2.52–2.65	2.54–2.65
>500	>500	>500	>450	>450	>500	>500	>500	>500
10$^{15-16}$	10$^{15-16}$	10$^{15-16}$	10$^{16-17}$	10$^{16-17}$	10$^{18-19}$	10$^{18-19}$	10$^{18-19}$	10$^{18-19}$
1.6–1.9	1.6–1.9	1.6–1.9	1.6–1.9	1.6–1.9	1.6–1.9	1.6–1.9	1.6–1.9	1.6–1.9
300–600	300–600	350–550	350–550	375–575	350–600	350–600	350–650	375–650
10,000–18,000	10,000–18,000	10,000–18,000	10,000–18,000	10,000–18,000	10,000–18,000	10,000–18,000	10,000–18,000	10,000–18,000
0.002–0.008	0.002–0.008	0.002–0.008	0.002–0.008	0.002–0.008	0.002–0.008	0.002–0.008	0.002–0.008	0.002–0.008
not applicable	not applicable	not applicable	not applicable	not applicable	type 4	types 2 & 4	types 1, 2 & 4	types 1, 2, 3, 4

Monsanto Polyethylene

One of the most useful and versatile of all plastics, Monsanto Polyethylene, produced in a broad range of colors, is chemically inert, non-toxic and odorless. Products molded from Monsanto Polyethylene resins are tough and resilient with a high impact resistance and flexibility over a wide temperature range. Monsanto Polyethylene products have extremely low dielectric constant and low power loss factor. Pelletted molding compounds are available for injection, compression or blow molding over a wide flow range 0.5—30 melt index. Readily processed in a broad range of colors.





typical applications

housewares
toys
industrial parts
packaging
"squeeze" bottles
vials
molded liners
closures

average property value	ASTM test method	706	805	935	975	8051	9352	9752
characterization								
melt index, gms./10 min. @190°C.	D-1238-57T	1.8	3.0	7.5	22	3.0	7	22
density, gms./ml.	D-792-50 D-1505-57T	0.917	0.917	0.916	0.916	0.921	0.926	0.926
density type	D-1248-58T	I	I	I	I	I	II	II
mechanical								
tensile strength, yield, psi	D-412-51T	1250	1220	1170	1100	1500	1900	1800
tensile strength, failure, psi	D-412-51T	2300	2100	1725	1400	1500	1400	1200
elongation yield, %	D-412-51T	100	100	100	100	50	25	25
elongation, failure, %	D-412-51T	740	720	640	600	430	350	150
tensile elastic modulus, psi	D-638-58T	23,000	23,000	22,000	22,000	27,000	30,000	30,000
hardness, shore	D-676-58T	C73, D53	C73, D53	C73, D53	C73, D53	D55	D56	D56
thermal								
low temp. brittleness, 50% failure at °C.	D-746-57T	<−75	<−75	<−70	<−60	<−75	<−60	<−50
°F.		<−103	<−103	<−94	<−76	<−103	<−94	<−76
specific heat, cal./gm./°C.	———	0.50	0.50	0.50	0.50	0.50	0.55	0.55
flammability. in./min.	D-635-56T	1	1	1	1	1	1	1
electrical								
dielectric constant @1 mc.	D-150-54T	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3
dissipation factor @1 mc.	D-150-54T	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
chemical								
moisture absorption, %.	D-570-57T	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
environmental stress cracking resistance	———	excellent	excellent	fair	poor	excellent	fair	poor
processing								
apparent (bulk) density, lbs./cu. ft.	D-1182-54	33	33	33	33	33	33	33
cylinder temperature. °F.	———	270–650	270–650	270–600	270–600	270–650	280–600	260–550
injection pressure, psi	———	5,000–15,000	5,000–15,000	5,000–14,000	4,000–13,000	5,000–16,000	5,000–15,000	5,000–14,000
mold shrinkage, in./in., on injection molded pieces	———	0.010–0.040	0.010–0.040	0.010–0.040	0.010–0.040	0.010–0.040	0.010–0.045	0.010–0.045

OPALON
vinyl chloride

Opalon molding powders feature outstanding heat stability, moldability, short molding cycles and low shrinkage. Available in granular form and as dry, free-flowing, dustless powders for injection and compression molding. Opalon molding materials are resistant to moisture, oxidation, most acids and alkalies, many common organic solvents, and petroleum. They can be formulated as opaque, translucent, or transparent compounds.

typical applications

appliance parts
toys
masks
goggles
swim accessories
grommets
sporting goods
handles
knobs
coil forms
housings
wiring devices
electrical system components
housewares
phonograph records

property	ASTM test method	75167	1308	1219	1221	9002	9201	1406
characterization								
specific gravity	D-792	1.45	1.39	1.36	1.39	1.31	1.48	1.38
mechanical								
tensile strength—failure, psi	D-412	1750	2450	2350	2200	2100	2200	2800
modulus @ 100% elongation, psi	D-412	800	1150	1150	1200	1350	1800	2100
elongation, %	D-412	360	370	355	360	300	260	320
hardness, Shore	D-676	A70	A80	A83	A87	A90	A92	A93
thermal								
cold flex. temp., °C	D-1043	−30	−18	—	−22	—	—	−8
brittle temp., °C	D-746	—	—	−42	−29	—	—	−14
heat aging—7 days retention of elongation, % @ °C	U.L. st'd's.	—	80@100°	98@100°	85@100°	—	—	90@136°
flammability, pass or fail	U.L. st'd's.	—	pass	pass	pass	—	—	pass
deformation @ 120°C, %	U.L. st'd's.	—	45	30	28	—	—	31
electrical								
volume resistivity, ohm/cm x 10^{12}	D-257	—	1	2	1	—	50	7
dielectric strength, Kv	U.L. st'd's.	—	25	—	—	—	—	25
power factor, immersed in water, 1000 cps. @ 30°C	D-150	—	0.10	—	—	—	—	0.11
processing								
molding stock temp., °F	—	350	355	360	370	360	370	385
applications		general purpose, good outdoor weathering	general purpose, cords, plugs	low temp. use	general purpose	lead free, shoe uppers, straps, general purpose	shoe heels, general purpose	105°C U.L. approval, odor free, polymeric plasticized

ULTRON

vinyl film

Ultron vinyl film is available in standard formulations or may be specially developed with "built-in" properties to meet specific end-use requirements. Produced in gauges up to .020″ and widths up to 80″ in a wide range of transparent and opaque colors. Ultron film is noted for its uniformity of gauge and color clarity. Tasteless, odorless, tough, pliable and long lasting, Ultron film is highly adaptable to various manufacturing techniques such as heat sealing, cementing, molding, laminated, printing, and embossing.

typical applications

moisture vapor barriers
protective coverings
wall coverings
industrial tapes
machine covers
agricultural applications
laminating materials for:
  sheet building materials
  flooring
  glass batt insulation
  metals
  paper
  fabrics

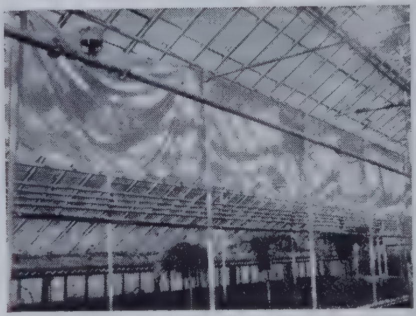
---

vinyl sheet

Ultron rigid vinyl sheets feature high dimensional stability, mechanical strength and toughness, high softening temperature, flame resistance, excellent light stability and chemical resistance. Available in rolls from .0075″ to 0.020″ and in widths up to 75″, also in sheets 21½″ x 51½″ untrimmed in gauges up to .125″. Greater thickness upon request. Matte, calendar and high polish finishes are obtainable. Ultron sheets can be printed, die cut, machined, vacuum formed, cemented, hot air welded, electronically sealed, embossed, planished, laminated, and corrugated.

typical applications

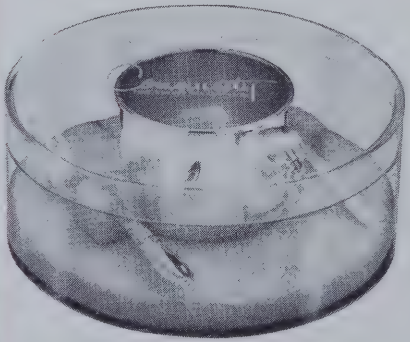
printing stock
displays
vacuum forming



VUEPAK

cellulose acetate

Vuepak is a crystal clear, rigid acetate that is readily fabricated into boxes and containers of outstanding appearance and sales appeal. Available in continuous, untrimmed and slit-to-size rolls up to 60″ wide and 2000′ long, in thicknesses from .005″ to .020″; and, in stock size sheets or cut-to-size pieces. Vuepack is adaptable to various fabricating methods such as shaping, drawing, folding and scoring, and may be printed, embossed, stapled or cemented.



typical applications

transparent windows
fabricated parts
protective laminates
diagrammatic drawings
rigid containers
displays
canisters
transparent inserts
filing tabs
wallet envelopes
protective envelopes

extruding and calendering materials

PLASTICS

LUSTREX
styrene

Monsanto Lustrex Hi-Test 88 styrene is furnished in pellets, either natural or colored. It may be extruded as sheeting or as profile shapes for various applications requiring high impact strength.

typical applications

- *refrigerator door liners*
- *toys*
- *lighting fixtures*
- *refrigerator breaker strips*
- *games*

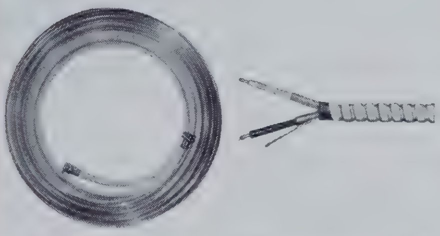
OPALON
vinyl chloride

Opalon resins, produced in several formulations for diversified industrial applications include . . .

. . . 300, 300FM, 330FM resins supplied for calendering and extrusion are especially recommended for dry blending, provide color depth, uniformity, toughness, and flexibility at low temperatures.

. . . 506, 306, 510, 510-26—for ease of processing.

. . . 410—a specially developed paste resin for vinyl plastisol compounding, supplied as a "stir-in" powder to increase speed and ease of preparation.



typical applications

- *phonograph records*
- *cable insulation*
- *rainwear*
- *upholstery*
- *floor tile*
- *Coatings (metal, paper, fabrics, and glass)*
- *foams*
- *sponges*
- *garden hose*
- *slush moldings*
- *dipping operations*

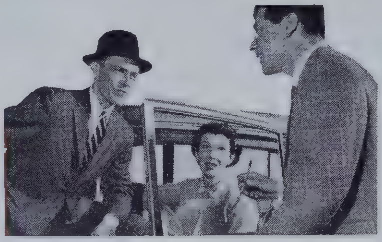
Monsanto Polyethylene

In pellets—natural or colored—Monsanto Polyethylene resin may be extruded as film and sheeting, wire insulation, piping, tubing, and profile shapes. Can be calendered into film and sheeting and laminated immediately or in subsequent operation. Non-slip and slip grade formulas available over broad melt index range.

typical applications

- *packaging films*
- *vapor barrier material*
- *agricultural films*
- *wire and cable insulation*
- *extrusion coatings*
- *profile shapes*
- *high clarity films*
- *packaging and barrier laminations*

laminating materials



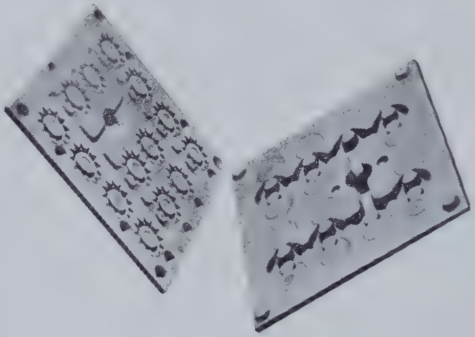
SAFLEX
vinyl butyral

industrial resins

for bonding

RESINOX
phenolic

LYTRON
synthetics



for foundry

RESINOX
phenolic

for laminating

RESIMENE
melamine

RESINOX
phenolic

textile resins

RESLOOM

RESLOOM E-50

LYTRON

STYMER

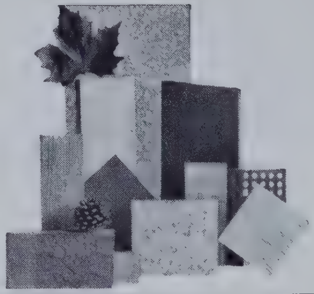
CATALYSTS

forms and typical uses	characteristics
A continuous adhesive film supplied in clear, tinted or gradated color, for the plastic interlayer in laminated safety glass. Industrial uses include light control and safety applications, Saflex can also be printed in decorative patterns or used for laminating imbedments between glass for room dividers, interiors and exterior doors, shower stalls, and table tops.	excellent transparency and toughness good adhesion

Furnished in liquid resins as coating or bonding material for Resinoid grinding wheels, clutch facings, brake linings, separators for automotive batteries, oil and chemical filters. Combined with Resimene resin for glass and rock wool thermal and acoustical insulation.	high heat resistance maximum bond strength good chemical resistance
Used in powder form for foundry sand and wash water clarification systems. In either powder or liquid form, they are used as thickening agents for paint and rubber latex.	maximum clay balling high workability high packability
Produced in liquid or dry-powder form as hot and cold coating resins for sand in the production of shell molds and cores.	non-dusting free-flowing rapid curing
Available in water-alcohol, soluble, spray-dry powders, Resimene resins form laminates with paper, cloth, glass and asbestos fibers to provide a durable surface for all types of furniture, counter tops, cabinets and walls.	high electrical arc resistance heat and flame resistance chemical and weather resistance strength and durability color stable
Supplied in water or alcohol solutions for treating laminate filler materials—paper, cloth, wood veneers, glass or asbestos fiber. Used in decorative core stock and electrical grade laminates for radio, TV and home electrical appliances as well as gears, ball-bearing races, pulleys, bushings for light and heavy machinery, cars, planes and ships. Special high heat resistant formulations are available for use with glass, asbestos and similar fillers for jet and rocket components.	toughness and durability resists acids and weak alkalies heat resistance to 350°F

Available in powder or liquid form as a series of essentially monomeric melamine resins. Used to impart shrinkage control, wrinkle resistance and textural effects to cotton, rayons, synthetics and wools.	permanently effective to fabrics made from a wide range of textile fibers.
Supplied as 50% solids cyclic ethylene urea formaldehyde resin in liquid form. Gives permanent textured effects, dimensional stability and wrinkle resistance to cottons, rayons and other synthetics.	assures permanent finish for textiles
Unplasticized polystyrene emulsions to produce coatings and finishes without curing or aftertreatment.	durability long life
Produced in various forms as sizing for acetate, rayon and other synthetic fibers. Stymer LF is vinyl resin, soluble in ammonium hydroxide. Stymer R is vinyl resin, soluble in water. Stymer S is styrene copolymer resin, soluble in water.	permanence for treated fabrics
Organic catalysts furnished in four types: AC, AC-2, AC-4 and AC-6 for textile applications. Provide efficient cure of melamine and cyclic-urea resins to give rayons, cottons and synthetics full effect of resin treatment.	rapid curing permanence uniformity of resin cure

adhesives



urea and melamine

phenolic and resorcinol

casein and soybean

paper and coating resins

OPALON

Monsanto Polyethylene

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surface coating resins

RESIMENE

RESINOX

LYTRON

LYTRON

intermediates

STYRENE MONOMER

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FORMALDEHYDE

forms and typical uses	characteristics
For hot and cold pressing, plywood and chip board products, radio frequency equipment.	weather resistance quick setting high gluing strength
Available in dry powders and liquids for cold pressing, hot pressing and granulated wood molding.	durability water resistance
Bonding and cold-setting glue bonding. Used for interior plywood, doors, laminated products, furniture, nail pressure gluing.	water resistance low temperature

Supplied as a powder, Opalon vinyl chloride paste resins are used in coating cloths and paper.	high tear strength low temperature flexibility resistance to weathering and aging
Furnished as pellets and compounds for use as wax reinforcement for paper or board coatings.	high gloss and scuff resistance strong heat seal improved printability
Scriptite 33, melamine-type resin supplied as a dry powder, and Scriptite 40, urea-type supplied as transparent colloidal solution, are used to create improved wet strength paper. Scriptite 50, 52 and 54, polyelectrolyte resins, supplied as dry powder, improve surface characteristics and printability of paper products.	ease of application maximum solubility excellent wet strength and printability

Melamine and urea-formaldehyde resins supplied in organic liquid solution for improved baked enamels.	improves surface hardness color retention promotes fast cure imparts weathering, alkali and chalk resistance
Phenolic liquid solutions for baked enamels and industrial finishes on can, drum and tankcar linings, special primers and coatings.	imparts high heat resistance promotes good chemical resistance
Alkali-soluble and water-soluble resins used in water and latex coating systems. Polyelectrolyte resins for protective coatings.	promotes adhesion stabilizes, hardens, thickens
Plasticized or unplasticized latices are used as main vehicles for latex paints and as modifiers in compounding rubber and other latices.	

form	uses
liquid inhibited with TBC.	styrene molding compounds, synthetic rubber, copolymers, ion exchange resins, polyesters, styrene modified oils and alkyds for surface coatings.
liquefied gas shipped either inhibiter free or inhibited with phenol.	polyvinyl chloride resins, compounds, copolymers and chemical intermediates.
liquid.	used for the manufacture of formaldehyde, as an antifreeze, as a solvent, a denaturant, and as a chemical intermediate.
liquid inhibited with Monsanto MQ inhibiter.	synthetic textile fibers, nitrile synthetic rubber, copolymers and chemical intermediates.
37% aqueous solution inhibited with methanol.	a preservative, disinfectant and chemical intermediate used in preparation of melamine and phenolic resins.

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selecting the right material

The selection of the right plastic material for your requirement is dependent upon many factors.

The illustrations and property values shown in this catalog are designed to merely serve as a guide to ultimate selection of a Monsanto resin for your product. Before a final choice is made, every effort should be made to discuss your application with Monsanto engineers, during the earlier phases of design. Their experience with plastic materials and methods may save you time and expense.

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Stiffness	psi	D747-50	15,000-50,000	130,000-175,000	120,000-240,000
Rockwell Hardness	—	D676-55T	*	R85-R95	R103-R118
Vicat Softening Point	°F	D1525-58T	185-238	285-290	351-401
Heat Distortion Temp					
66 psi	°F	D648-45T	105-175	210-230	330-360
264 psi	°F	D648-45T	*	130-140	155-165

*Not applicable.

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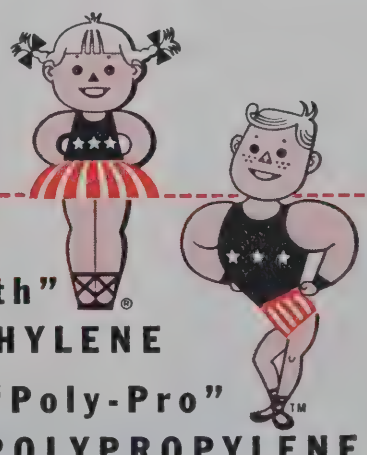

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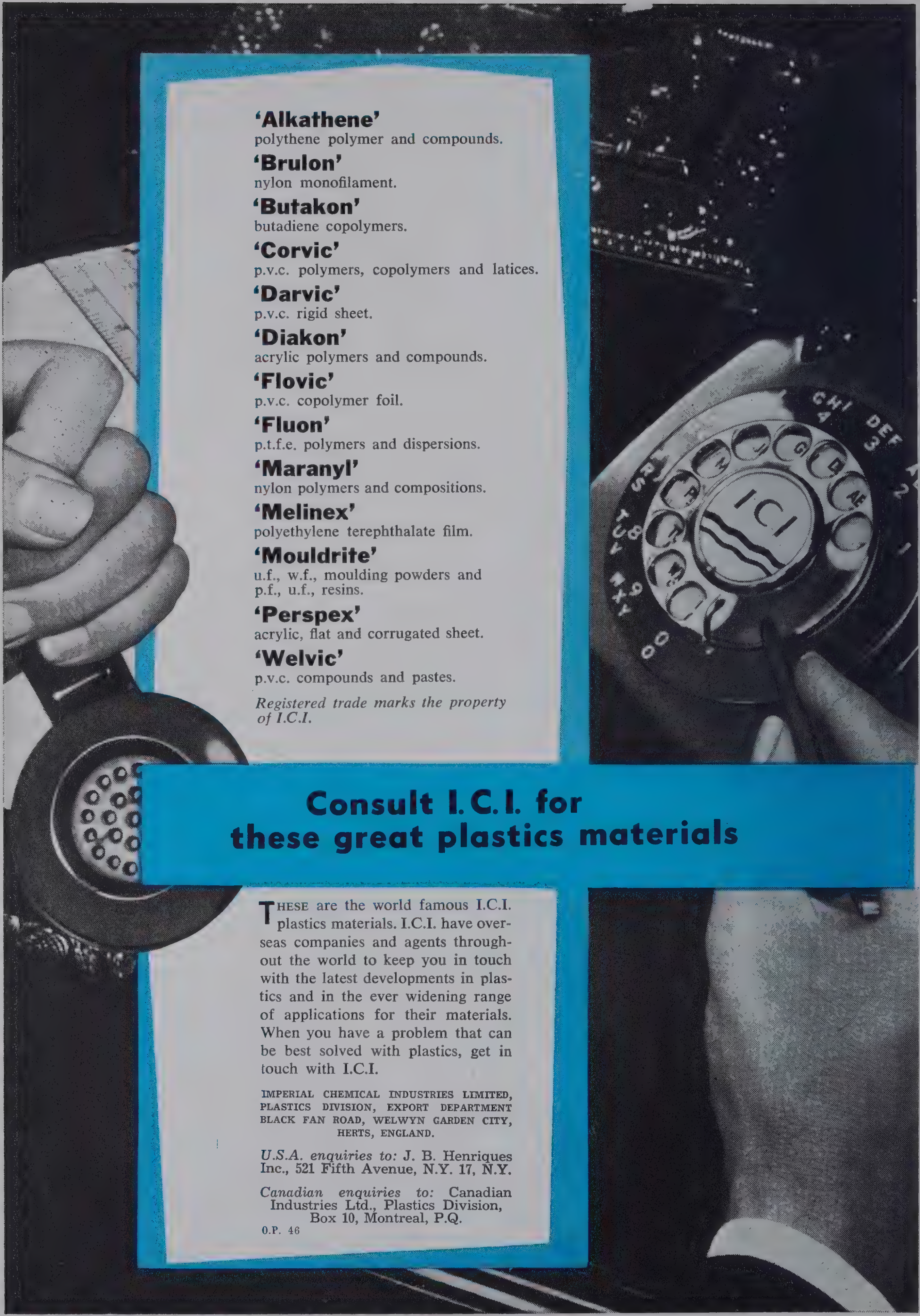

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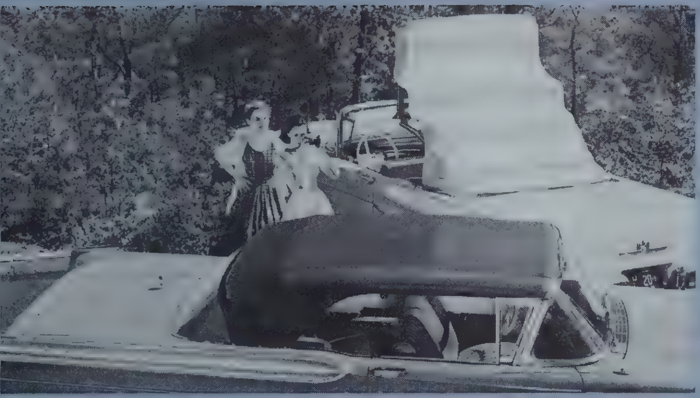
News about

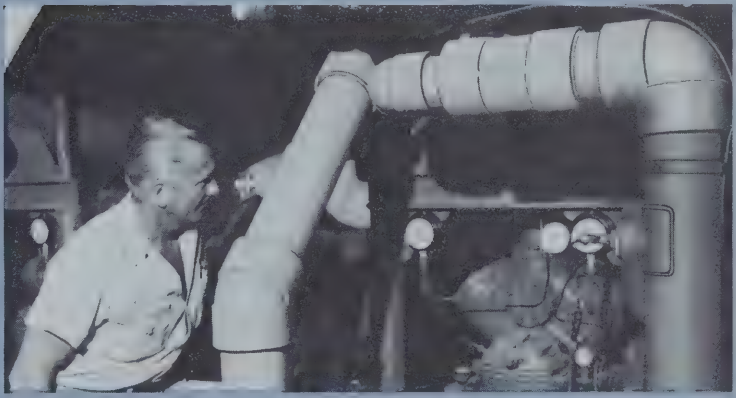
B.F.Goodrich Chemical

raw materials

Hobby horse of Geon is rotationally cast in one piece



Convertible tops get fade-proof color from Geon coating



Conduit and pipe of Geon solve corrosion problems

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In any of the widely varied forms in which they are available, Geon polyvinyl materials provide an excellent combination of properties. Geon provides inertness or resistance to chemical attack. It offers superior electrical properties and adaptability of physical properties to meet a broad range of requirements.

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Geon has proved again and again—in thousands of products—its unusually high qualities of uniformity and reliability. The experience of B.F.Goodrich Chemical Company with this outstanding polyvinyl material dates to 1939. As a result the company's Technical Laboratory can place at your disposal twenty years of experience with this outstanding polyvinyl material. It is uniquely equipped to help you apply Geon raw materials to produce dramatic new or improved raw materials.

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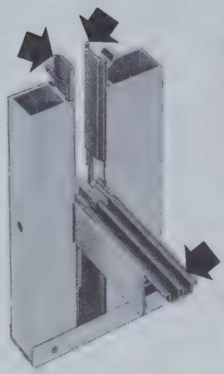


Weatherstripping extruded of rigid Geon seals out weather, lets aluminum-framed windows slide easily.

EXTRUSIONS

Geon polyvinyl materials are easy to extrude. The range of products is extremely wide—from tubing and hose to belting, trim, gasketing, tape, and ductwork. Geon is also extruded as a covering for other materials.

Conduit of extruded Geon rigid vinyl solves corrosion problems for utility installation.

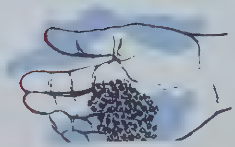
GEON . . . *versatile key to*

The four basic forms of GEON MATERIALS

resins

are free-flowing white powders generally requiring compounding with other ingredients to produce plastics.

plastics



are resins compounded at our plants ready for extrusion or molding. A large number of compounds in cubical form are available in a wide range of colors especially formulated and tested for specific uses.

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ions of polyvinyl chloride polymers sup-
ilk-white liquids of approximately 50%
y form clear, tough films or coatings and
ded to give opaque or colored deposits.

cized with Hycar® nitrile rubber, sup-
imilar in appearance to crude rubber.
asticizer provides the advantages of non-
r such applications as food packaging
ing.

FOAM AND SPONGE

To make vinyl sponge, a chemical blowing agent is incorporated into a plastisol and fusing is done under high pressure in a mold. The blowing agent decomposes under the heat to liberate a gas which expands the vinyl. Foam is made by dissolving an inert gas in a plastisol under relatively high pressure and releasing it through a spray nozzle into a mold or onto a casting surface. Fusion is then done by dielectric heat. Continuous production of vinyl foam is possible under this method (patents held by Elastomer Chemical Company and by Dennis Chemical Company).

Donut-shaped part for automobile is rotationally cast, then filled with foam of Geon to provide resilience for sound and vibration damping.

dramatic new or improved products

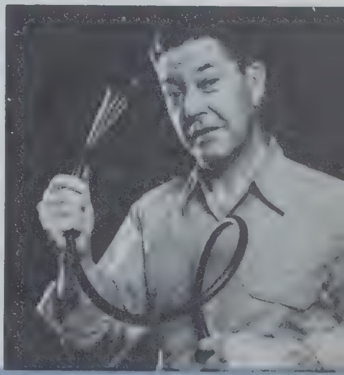
MOLDING

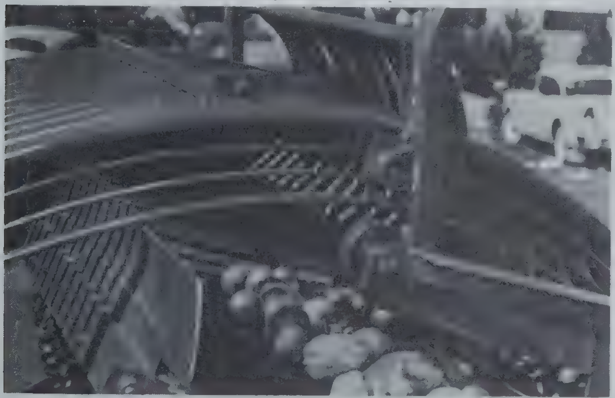
No process better demonstrates Geon's versatility than molding. High fidelity phonograph records are compression molded. Pipe fittings are injection molded. Slush- or low-pressure molding of Geon plastisols is used for dolls, toys, fish lures and gaskets.

All parts of this plug valve, including wrench, are molded of Geon polyvinyl material, show complicated shapes possible.

Glass fibers are coated with Geon to produce flexible, rustproof, resilient screening that is easy to install.

INSULATION made from Geon polyvinyl compounds and resins offer outstanding advantages: Excellent dielectric properties and good resistance to abrasion, weathering, and heat; as well as non-flammability, low temperature flexibility, and extreme inertness to oil, chemicals and solvents. Geon will retain its properties over many years of severe use, indoors or out.





Potato harvester has conveyor bars coated with vinyl foam of Geon to give perishables bruise-free treatment.

CALENDERING AND COATING

Geon is used to coat a wide range of materials, for both decorative and functional coatings. Coating materials include Geon latices, preferred where thin coatings are desired without use of volatile solvents; Geon resins for plastisols and organosols, preferre for medium and heavy coatings; solvent-solution systems, most useful for thin coatings, particularly where high gloss or transparency are desired. Geon latices can also be used to make a continuous sheet of random or oriented fibers in making non-woven fabrics.

Other outstanding raw materials by B.F.Goodrich Chemical Company

Hycar Hycar dry rubbers are uncompounded polymers that include the oil resistant nitrile types, a polyacrylic for high temperature use, and a brominated butyl with exceptional characteristics of compatibility and cure. Compounding with vulcanizing agents, loading pigments and softeners is easily accomplished on conventional rubber equipment. Hycar rubbers are also supplied as water dispersions or latices that reflect the properties of their dry rubber component. Generally, Hycar materials are resistant to oil, solvents, and abrasion, have low compression set, and good aging qualities.

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Good-rite chemicals include antioxidants, hydrophilic polymers, and chemical intermediates. They have an outstanding reputation for purity and dependability. Experimental samples and further information are available on request.

Carbopol Carbopol 934 is a hydrophilic polymer available in powder form to instantly gel formulations of water, alcohols, glycol or glycerine—or their combinations—when neutralized. It produces formulations with excellent body and staying power, yet which can be stirred or pumped as readily as a light, airy material. It serves as an excellent stabilizer in liquids containing two or more incompatible ingredients. Carbopol also promotes easy spreading qualities and is compatible with most materials used in water base dispersions.

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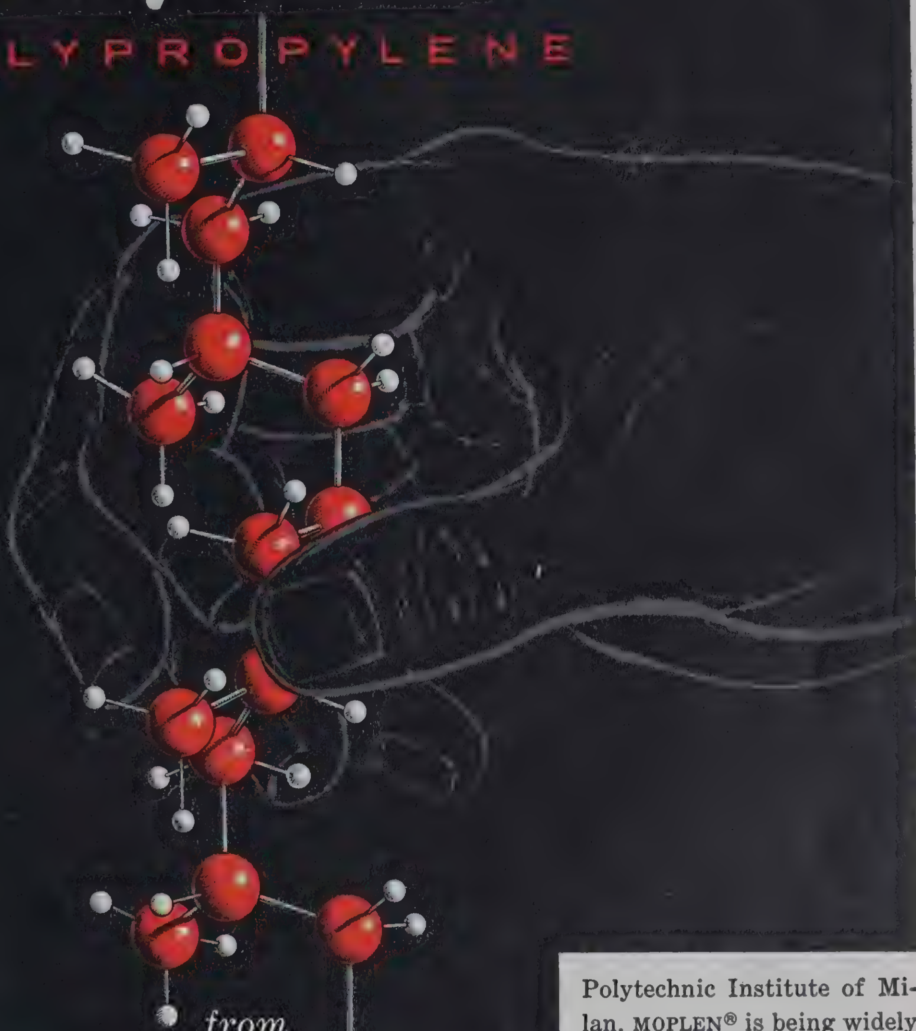

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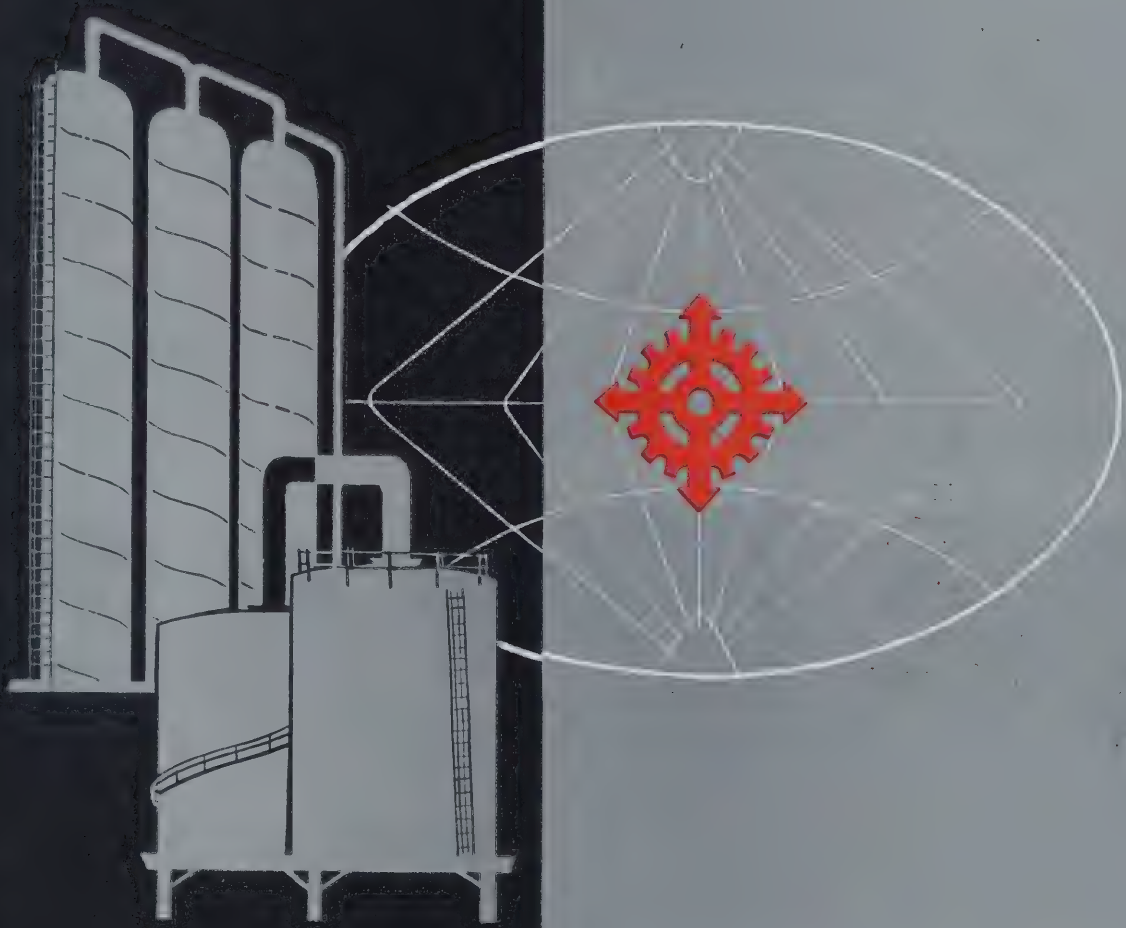

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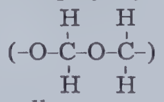
RESINS AND MOLDING COMPOUNDS

Acetal resins . . . *from pilot plant to production*

By E. F. Hamilton, Jr.*

After two and a half years of extensive field evaluation, acetal resin (Delrin[1]) went into commercial production during 1959. The molecular structure of the polymer is that of a linear acetal, consisting of unbranched polyoxymethylene chains



$$(-O-\overset{H}{\underset{H}{C}}-O-\overset{H}{\underset{H}{C}}-)$$

of great length, normally averaging more than 1000 CH_2O units.

The high crystallinity and melting point (347° F.) of the resin accounts for an excellent combination of properties which makes it a suitable replacement for metals in numerous applications. High strength and stiffness, good fatigue life, exceptional resilience, and toughness combine with low moisture sensitivity, high solvent resistance, and excellent electrical characteristics to give the material a high degree of versatility. A major feature of the polymer is its retention of these properties at elevated temperatures. Field evaluations in precommercial end uses have substantiated early laboratory tests, which indicated that the resin would be excellent for producing automotive, appliance, machinery, and consumer items.

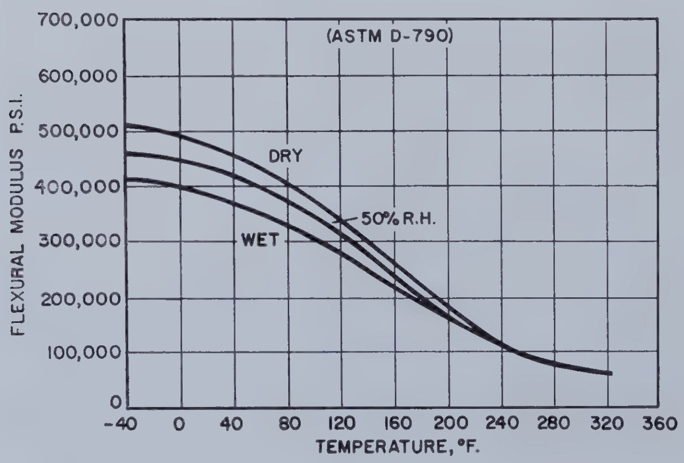
Injection molding powders (Delrin 500) and extrusion powders (Delrin 150) are available in natural and colored compositions. Natural Delrin is an opaque white, which makes possible an unlimited number of colored compositions. Its colorability is excellent; colored products have a sparkle and brilliance believed to result from its very high crystallinity.

The colors of the 500 and 150 materials retain their strength properties well on outdoor exposure, but tend to chalk. However, a line of UV stabilized colors with good weatherability is offered in the Delrin 507 and 157 series.

Properties

Typical properties of acetal resin are given in the Plastics Properties Chart, opposite p. 512. The extrusion grade material has the higher elongation and impact strength; consequently, it is tougher than the molding grade. Other than these differences, the two compositions have the same properties.

Mechanical: One of the strongest and stiffest thermoplastics, Delrin has a tensile strength at room temperature of 10,000 p.s.i., with no true yield point, and a flexural modulus of 410,000 p.s.i. Moisture has slight effect, changing strength properties only 10 to 20% (Fig. 1). Strength retention at elevated temperature is usually good: even at 200° F. tensile



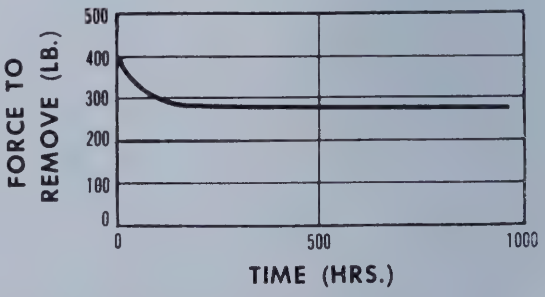


FIG. 1 (LEFT): Flexural modulus of acetal vs. temperature and moisture. **FIG. 2 (ABOVE):** Creep resistance is shown by stress relaxation curve of rod forced into a 0.009-in. smaller hole. Pieces were exposed to 200° F. and then cooled; force to remove was measured at room temperature

strength is 6000 p.s.i. and flexural modulus is 180,000 p.s.i.

---

*Product technologist, Polychemicals Dept. E. I. du Pont de Nemours & Co., (Inc.), Wilmington 98, Del.

[1] Trademark of Du Pont.

References were prepared by the editors.

In creep resistance, particularly under prolonged high loadings and humidities, acetal resin shows a pronounced superiority over most typical thermoplastics. Its creep resistance is demonstrated graphically in Fig. 2, which shows the stress relaxation of an interference fit stored at 200° F. Resistance to creep is also reflected in high fatigue endurance limit, which at room temperature and 100% relative humidity is 5000 p.s.i., and is still 3000 p.s.i. at 150° F. Lubricants and water have little effect on the fatigue life.

For its strength and stiffness, this polymer is one of the toughest, most resilient thermoplastics known. Of striking importance is the slight effect of temperature on its toughness: the Izod impact strength is essentially constant from —40 to 212° F. Moisture also has little effect on toughness.

Chemical resistance: This acetal resin is unusual among thermoplastics in its resistance to organic solvents. There are no common solvents at room temperature. This property gives it excellent stain-resistance at room temperature for foods such as tea, catsup, vinegar, margarine, lemon juice, beet juice, and mustard, as well as resistance to such industrial materials as oils, greases, typewriter ribbon inks, and hectograph duplicating masters. On the other hand, the polymer is not recommended for contact with strong acids and bases, and tests should be run on specific applications for use in weak acids and bases.

Dimensional stability: The low moisture absorption of this material gives it excellent stability. After equilibrium has been reached at room temperature, the polymer increases in dimension only 1 mil/in. in going from 0 to 50% relative humidity, and only 4 mils/in. when totally immersed in water.

Abrasion and frictional resistance: The abrasion resistance of the polymer is generally superior to other thermoplastics, with the exception of nylon. It exhibits clean wearing characteristics and particles from the abrading surface generally do not embed in the acetal resin.

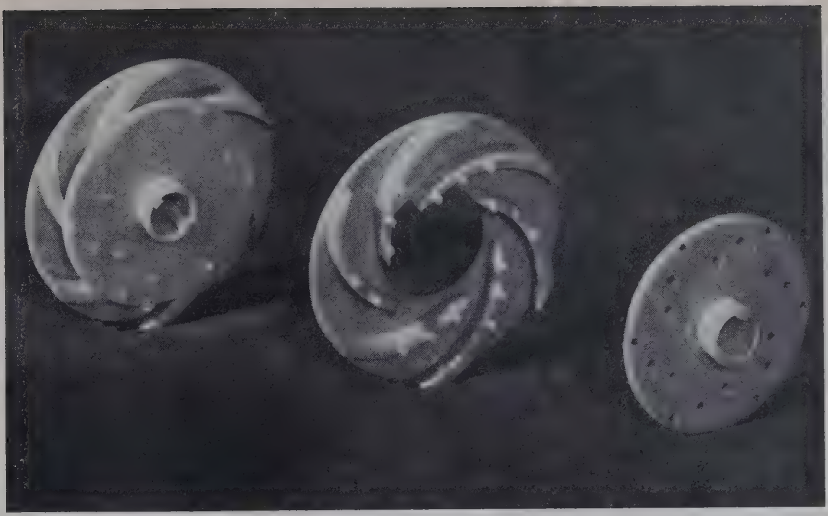


FIG. 3: Water pump parts (center and right) molded of acetal are assembled (left) by using heating tool that upsets heads on molded-in prongs

The hard, smooth surface of acetal gives it a slippery feel. Its coefficient of friction on steel is very low (0.1 to 0.3 by inclined plane test) and shows little variation from 73 to 250° F. and under loads up to 2500 p.s.i. Its static and dynamic coefficients are equal, hence the phenomenon of slip-stick has not been observed.

Electrical: Excellent electrical properties are combined with the exceptional mechanical characteristics of acetal resin. Low dissipation factor and dielectric constant prevail over a wide range of frequencies and up to temperatures of 250° F. The polymer maintains its good electrical properties under high humidity exposure and after immersion in water. This resin should prove to be an ideal insulator for applications where good electrical properties are required in conjunction with high strength, abrasion resistance, dimensional stability, and property retention at high temperature.

Processing

Acetal resin is best suited to processing by injection molding and extrusion. A large variety of shapes and forms, including sheet, pipe, tubing, and rod, can be produced on conventional extruders.

Fabrication by hot-gas, hot-plate, and resistance-welding methods work well with acetal. Standard commercial fastening devices can be used such as explosive rivets and self-tapping screws. Of the latter, thread-cutting types ASA F or T are recommended. Fastening can also be done by nailing or cementing. Although cementing is difficult because of the resin's excellent solvent resistance, several commercial adhesives can be employed where bonds of acetal to acetal are desired.

Machining qualities are similar to free-cutting brass and permit the production of parts on automatic screw-cutting machines. These qualities also enable shaping by filing, surface-grinding, and similar operations. High gloss can be imparted by standard polishing techniques.

Spray-applied commercial lacquers using the conventional industrial technique of a primer-top coat system followed by a 310° F. baking period produce finishes of beautiful appearance on molded acetal parts. These coatings successfully pass the pressure-sensitive tape adhesion test commonly used in the paint industry. Parts can also be vacuum metalized, printed by direct screen, or hot stamped with roll leaf.

Applications

Impellers and other components for domestic water pumps, which must retain high strength and stiffness on continuous exposure to water, take full advantage of the combination of low moisture absorption and high strength and stiffness of this resin. The two-piece molded impeller for a multistage, deep-well pump shown in Fig. 3 is a good illustration. Prongs

FIG. 4: Molded acetal zippers are strong, have excellent frictional characteristics and are easy to operate. Action is not affected by high humidity or contact with corrosive salt spray

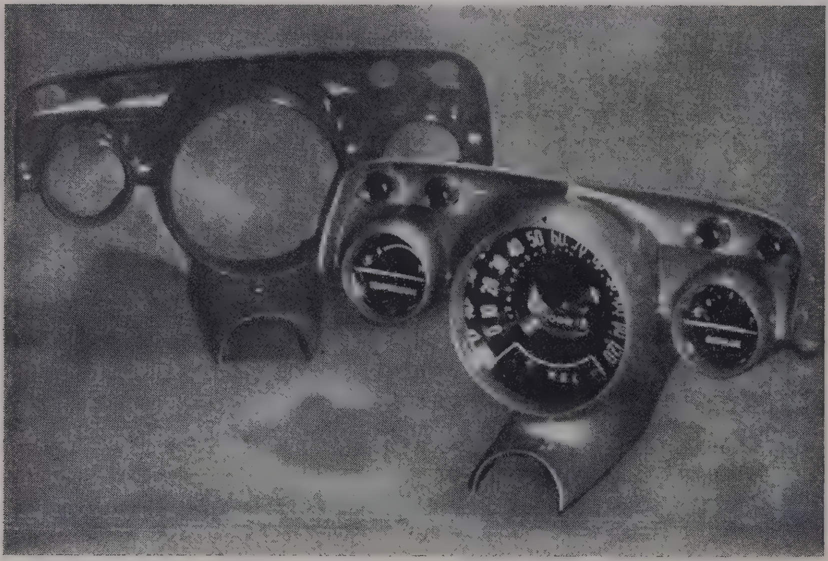


FIG. 5: Instrument cluster is another application for molded acetal; 80% lighter in weight than zinc, it securely holds self-tapping screws

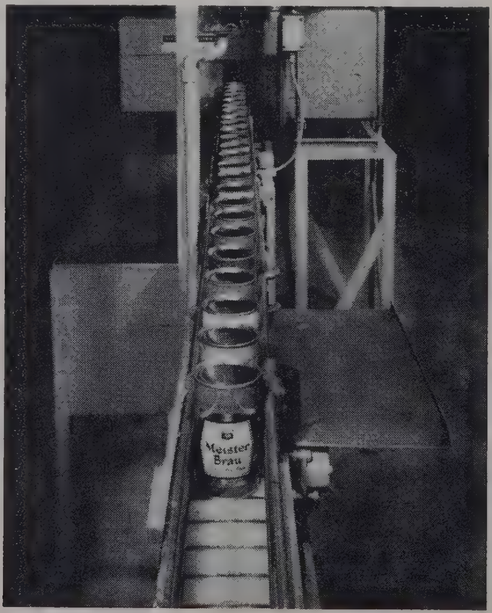


FIG. 6: Anti-friction properties and corrosion resistance of molded table-top conveyor parts enable them to serve as their own bearings

and mating holes are provided for permanently joining the two halves by applying a heating tool which simultaneously, in one quick production step, upsets a head on each of the prongs. This is a fast and economical method for joining two molded acetal parts.

The high strength, stiffness, and resiliency, with excellent frictional characteristics are properties which permit acetal resin to be used in zippers (Fig. 4). In addition, the smooth action of the zipper is not hampered by high humidity, nor destroyed by corrosive salt spray. It will withstand laundering and dry cleaning without damage.

The instrument cluster shown in Fig. 5 is almost 80% lighter in weight than zinc which is normally used, and thereby offers a reduction in shipping cost and ease of handling during assembly. The ability to hold self-tapping screws without subsequent loosening due to creep or stripping is very important in this application. Clusters can be molded in integral color or painted.

In applications involving friction, it is often possible and economically desirable to make the molded object serve as its own bearing. The table-top conveyor shown in Fig. 6 has this "two-in-one" feature because of the anti-friction properties and corrosion resistance of its molded acetal parts.

Lawn mower and push cart wheels are other examples where this "two-in-one" principle can be used. Tests also indicate that extruded acetal tubing provides an excellent control-cable housing for throttle and steering controls on machinery and boats.

References

Consult Subject Index for additional information on acetal resins. For sources of acetal, see the Directory Index on p. 1078.

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Acrylics

By F. J. Glavis[*] and Helen F. Tucker[*]

pments...Recent Developments...Recer

Extrusion grade methacrylate resin (*Lucite 147,* Du Pont) makes possible embossing of the warm sheet as it comes out of the extruder . . . is expected to have economic advantages over cast sheet where optical properties are not critical . . . auto and boat trim, building facings and decorations, fluorescent lighting, and signs are potential markets.

Modified methyl methacrylate resin (*MX409,* Amcel Co., Inc.), for reinforced plastics uses, exhibits good resistance to discoloration, surface degradation, and loss of translucency.

Transparent methacrylate polymer (*PL-11,* J. T. Baker Chemical Co.), for injection molding and extrusion, has heat distortion temperature of about 250° F. . . . is similar in mechanical and optical properties to other methacrylates . . . has been immersed indefinitely in boiling water without affecting its water-white transparency. A second series (*PL-12*) has a heat distortion point of 240° F. . . . is not as clear as *PL-11*, but has much higher impact strength.

Monomers and polymers of acrylic, substituted acrylic, and methacrylic acids, their salts, esters, and other derivatives, such as nitriles and amides, make up the acrylic family.

Acid monomers and polymers: Acrylic acid, $CH_2=CHCOOH$, is a corrosive, weak acid, available in essentially anhydrous form (glacial). Reactions of acrylic acid are typical of normal acid functions (ester, salt, anhydride, and acid chloride formation) and of the unsaturated function (addition of halogens, amines, mercaptans; Diels-Alder reaction). All reactions are qualified by the molecule's polymerizable nature.

Polyacrylic acid, available as an aqueous solution in different viscosity grades and as an anhydrous powder, is a water-soluble polymer that gives hard, brittle, clear films. This product is capable of undergoing chemical reactions involving the acid function, such as salt formation and esterification, insolubilization being achieved in the latter instance by the use of polyfunctional alcohols. Methacrylic acid, available in anhydrous form, is similarly amenable to reaction of the two functional groupings in the molecule as well as to polymerization.

Both acrylic and methacrylic acid are used in the modification of the properties of polymers through incorporation of varying amounts of these monomers in copolymerization reactions. Improved hardness, solvent resistance, and increased hydrophilicity may be obtained. Introduction of the acid group permits vulcanization of the polymer with zinc oxide.

Salts: Monomeric salts may be prepared by neutralization of the corresponding acid or by suitable saponification of the appropriate monomeric ester. Solid sodium methacrylate is now available.

Polymeric acrylic salts may be prepared by 1) neutralization of the polymeric acids; 2) polymerization of the monomeric salts; 3) saponification of the polymeric acrylic esters; and 4) alkaline hydrolysis of the polymeric nitrile. For example, sodium polyacrylate made by the saponification of polyacrylonitrile is available from many sources. The potassium and ammonium salts are also produced. The polymeric salts are water-soluble polyanionics, giving hard, brittle, clear, hygroscopic films. In the presence of other cations, they show ion-exchange reactivity. The presence of acrylic salts as components of a copolymer system may affect the properties of the product so formed by alteration of the hydrophilic nature of the polymer, by insolubilization with polyfunctional cations, or by modifying hardness and brittleness.

Esters: A wide range of monomeric acrylic esters is available, with large quantities of methyl and ethyl acrylates and methyl methacrylate now being produced. Other available esters include butyl, 2-ethylbutyl, 2-ethylhexyl, octyl, methoxyethyl, ethoxyethyl, 3-ethoxypropyl and 2-diethylaminoethyl acrylates and ethyl, butyl, hexyl, decyl-octyl, lauryl, stearyl, 2-dimenthylaminoethyl, 2-diethylaminoethyl and t-butylaminoethyl methacrylates, and tetraethylene glycol dimethacrylate. These esters are capable of undergoing reactions of the ester group, and of the unsaturated system, including polymerization. Variation of the molecular make-up of copolymers, involving different acrylate and methacrylate esters as well as other polymerizable monomers, allows wide physical variations.

The polymeric esters may be considered from the point of view of the following polymerization methods:

1) The monomeric esters can be polymerized in bulk by casting techniques to give sheet materials.

2) Suspension polymerization of the monomeric esters has been used to prepare molding powders. The polymer can be produced in discrete particles of well-defined dimensions by control of the polymerization conditions. The molding powders are formed into hard, transparent, clear objects by ap-

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[*] Research Laboratories, Rohm & Haas Co., Washington Square, Philadelphia 5, Pa.

Recent developments and references were prepared by the editors.

LUMINOUS FACADES . . .

WEATHER RESISTANCE and high impact strength of translucent acrylic panels recommend them for building facade. Letters and trademark are formed of acrylic sheet. (Photos, Rohm & Haas)

plying heat and pressure in molds that are of the desired shape.

3) A third method involves the polymerization of acrylic esters in organic solvents. A large range of solvents has been used for the preparation of soluble polymers, the properties of which permit application in coating, adhesive, and lubricating oil compositions. By using different esters and combinations of esters, and modifications in the polymerization conditions, polymeric compositions having various solubilities result. These produce films that range from hard and brittle to soft and tacky.

4) By using emulsion polymerization techniques, a fourth type of polymer system has been made available. These stable dispersions of discrete particles of acrylic polymers may form films on drying. Depending upon the particle size of the polymer as well as upon its chemical composition, durable films may be obtained with varying hardness and tack. Reports have been published of methyl methacrylate polymers of regular configuration. Both the amorphous and crystalline forms of such polymers possess physical properties which are different from those of the conventional polymer. Such differences suggest new applications.

Nitriles: Acrylonitrile monomer is readily available from multiple sources. The monomer is a liquid capable of ready polymerization, and is reactive by virtue of both its carbon-to-carbon unsaturation and its nitrile function. Polymerization, which may be effected in aqueous suspension or in solution, provides the basic material for the preparation of fibers (Orlon[1] and Acrilan[2]). Polyacrylonitrile is soluble in such solvents as dimethyl formamide, ethylene carbonate, tetramethylene sulfone, and aqueous solutions of thiocyanate salts, and may be formed into fibers by extruding a polymer solution into a coagulating bath such as water. Polyacrylonitrile may also be hydrolyzed with acid, caustic, or ammonia to form water-soluble hydrolysates as indicated previously in the discussion of polymeric acrylic salts. Acrylonitrile is not amenable to bulk polymerization, since the polymer is insoluble in the monomer. Acrylonitrile is useful in copolymer systems to improve such properties as solvent resistance and hardness. Examples include copolymers of acrylonitrile with butadiene, styrene, and vinyl chloride.

Amides: Acrylamide and methacrylamide are available as solid materials. Both the monomers and polymers are susceptible to alkaline hydrolysis with the formation of ammonia and the corresponding acrylic salt. In addition, the amide function can be modified by reaction with formaldehyde to produce methylol acrylamide and methylene-bisacrylamide, both of which are currently available. Also available is N-tert-butyl acrylamide. Polyacrylamide has been introduced as an industrial flocculant.

Alpha-halogenated esters: The methyl alpha-chloracrylate, derived from methyl acrylate, has been investigated extensively as a material that affords, on polymerization, a hard, clear, transparent sheet with a high softening point and resistance to surface abrasion.

Alpha-cyano ester: Methyl

LARGE SIGNS . . .

A MAJOR MARKET for acrylic sheet is in signs. Sign at right measures 8 by 24 ft., has fabricated blue letters on translucent background

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[1] Trademark of E. I. du Pont de Nemours & Co., (Inc.).

[2] Trademark of Chemstrand Corp.

alphacyano-acrylate has been introduced as a readily polymerizable component of adhesive formulations.

The above chemical classification of the acrylics indicates the wide variety of properties that are obtainable with such materials. There are many instances in which minor proportions of acrylic monomers are useful in modifying the properties of polymer systems based on monomers other than acrylics. The following discussion of end uses will not include materials made with acrylic monomers in minor proportions, such as the butadiene rubbers, and copolymers with vinyl chloride and vinyl acetate, or with styrene.

Applications

Sheets and molding powders: The properties exhibited by solid acrylic polymers, such as crystal clarity, high impact strength, formability, and resistance to sunlight, weather, and most chemicals, have led to widespread use in military and civilian applications. The fields of usefulness have also been broadened by availability in transparent, translucent, and opaque colors.

Acrylic sheet is the standard transparent material for canopies, windows, instrument panels, and searchlight and landing light covers on aircraft. Large sheets, edge-lighted, are used as radar plotting boards in shipboard and ground control stations. To keep pace with the increasingly severe service requirements of pressurized jet aircraft, new grades of acrylic have been developed that have improved resistance to heat and crazing. The stretching technique has made possible enhanced resistance to both crazing and shattering.

In the general field of merchandising, acrylics have become a major sign material for faces and letters, particularly for outdoor use where weather resistance is important. In addition, acrylics are used for counter dividers, transparent demonstration models of household appliances and industrial machines, display fixtures and cases, and vending machines. The ability of acrylics to resist breakage and corrosion, and to transmit and diffuse light efficiently makes them beneficial in industrial and architectural application. Industrial window glazing, safety shields, inspection windows, machine covers, and pump components are some of the uses commonly found in plants and factories. Dome skylights formed from acrylic sheet are an increasingly popular means of admitting daylight through the roofs of industrial, commercial, and public buildings and of private homes. Acrylics are employed to good advantage as the diffusing medium in lighting fixtures and large luminous ceiling areas. Shower enclosures and decorative partitions are other well-established applications. An expanding development is a window glazing panel with integrally formed louvers for the control of sun and sky glare.

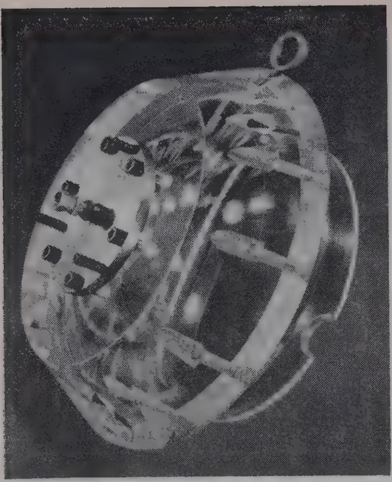
In molding powder form, acrylics are used extensively for the manufacture of automotive parts, such as taillight and stoplight lenses, medallions, nameplates, dials, instrument panels, and signal lights. The beauty and durability of molded acrylic parts have led to their wide use for nameplates, control knobs, dials, and handles on all types of home appliances, for pen and pencil barrels, and personal accessories such as hairbrush backs. Covers for fluorescent street lights, jukebox panels, TV implosion shields, and other large-section moldings are being formed from acrylic powder. The extrusion of acrylic sheet from molding powder is particularly effective in the production of thin sheeting. Extruded sheets have also been employed with success in such applications as sign-lighting, glazing, partitions, and shower enclosures.

Advantage is taken of the transparency, strength, light weight, and edge-lighting characteristics of acrylics in the fields of hospital equipment, medical examination instruments, and orthopedic devices. The use of acrylic polymers in the preparation of dentures is an established practice. The embedment of normal and pathological tissues in acrylics for preservation and instructional use is an accepted technique, which has been extended to include embedment of industrial machine parts as sales aids, and the preparation of various types of home decorative articles.

Elastomers: The use of various members of the acrylic family in synthetic rubber formulations may be exemplified by a copolymer of ethyl acrylate with about 5% of a chlorine-containing monomer such as chloroethyl vinyl ether or chloroethyl acrylate. The vulcanized products combine outstanding heat resistance and oil resistance, and have found widest use as gaskets for automatic transmissions for gasoline engines. Vulcanizates of fluorinated acry-

LIGHTING FIXTURES . . .

LIGHTING DIFFUSERS made from acrylic sheet are used in suburban bank. Acrylic has high light transmission and resists breakage



MASSIVE CAST acrylic blocks (Cast Optics Corp.) were used as stock from which instrument "viewing window" 16 in. diameter by 8 in. thick was machined

lics are said to offer advantages in toughness and durability. Acrylate-acrylonitrile copolymers are also being manufactured for use as vulcanizable elastomers. The use of acrylonitrile in the nitrile rubbers continues to offer products of superior solvent resistance and durability. Polyblends of acrylonitrile-styrene resins with butadiene-acrylonitrile rubbers are used for pipes and fittings in industrial applications in which resistance to alkali and acid is required.

Ion exchange resins: Cation exchange resins may be produced by the polymerization of methacrylic acid in the presence of cross-linking agents, such as di-vinylbenzine. For a discussion of this use of methacrylic acid, see article starting on p. 117.

Textiles: Studies of acrylic fibers, such as Orlon and Acrilan, have been concerned with modifications in molecular formulation to achieve greater dye receptivity, and mechanical modifications to reduce fibrilation and subsequent apparent color variations in dyed fabrics. Blends of polyacrylonitrile with such fibers as wool, rayon, and acetate provide a means of obtaining mixed fibers with the dyeability and other properties characteristic of the fiber types present in the blend. Certain synthetic fiber blends have been developed to simulate fur. Modification of cotton to give improved characteristics, such as fungus resistance and higher heat resistivity, has been achieved by treatment with acrylonitrile.

Acrylics are established materials for sizing fibers, with polyacrylic acid used extensively in the nylon field. Acrylate dispersions provide highly desirable types of finishes. Applied to cotton and rayon, they contribute a firmer hand, improved tensile and tear strength, and better abrasion and wear resistance. They are not easily removed by washing. Uses of an acrylic backing for upholstery fabric is an established practice. Acrylic dispersions have also found application as binders for nonwoven fabrics.

Coatings: Acrylic emulsion paints constitute a major expanding development. Specifically recommended for durability of finish, lack of odor, speed of drying, and ease of application, both the emulsion and compounded paints for interior and exterior use in pigmented formulations are available. Some formulations have been suggested for use over damp surfaces. Exterior use over masonry is an expanding application. Acrylic automotive finishes represent a growing field; enhanced durability and prolonged retention of luster are achieved, particularly with pastels. A thermosetting acrylic-base coating for appliances is also available.

For application by either spraying or brushing, acrylic coating solutions in organic solvents are available in types that give almost any desired range of hardness or tackiness, with clarity and durability a prominent feature. These acrylic coatings are for both decorative and protective uses, the scope of application ranging from protection of art treasures to resin treatment of raincoats. Decorative and metalized coatings can also be applied to plastics articles to enhance their appearance. Other coating applications include the use of water-soluble acrylic polymers in the thickening of resin-based coating formulations to a predetermined viscosity. In addition, such acrylic monomers as tetraethylene glycol dimethacrylate are used in coating and filling compositions, and as vulcanizable plasticizers in plastisol formulations.

Paper: Acrylic dispersions are used for clear, greaseproof paper coatings, as binders for clay coatings, and as adhesives.

Adhesives: Acrylic monomers find application as components of copolymers used in making pressure-sensitive tapes and bonding agents. They improve aging characteristics and adhesion.

Leather: Acrylic dispersions are used in leather-finishing applications. As a base coat for cellulose finishes, the acrylics produce permanently flexible and strongly adhering coatings. When dry, these are no longer water-dispersible, but are soluble in the customary lacquer solvents, so that excellent adhesion of subsequent lacquer coatings is obtained. As a component of water finishes for leather, the acrylic improves adhesion, flexibility, and leveling of the finish, and can improve washability. Greater dimensional stability of drying hides is achieved by water-soluble acrylic pastes.

References

Consult the Subject Index for additional information concerning acrylic resins. For specific information on injection molding, see p. 594. See also the Adhesives, Coatings, and Plastics Properties Charts for information on properties and trade designations. For sources of acrylics, see Directory Index, p. 1078.

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Amino resins

By C. E. Britt*

Amino resins are finding an ever broadening scope of new applications, particularly in the case of the two most important resins in this group, urea-formaldehyde and melamine-formaldehyde. The reason for their increasing popularity rests in the unique properties these versatile resins impart to an extremely wide range of seemingly unrelated end products.

The typical uses of amino resins include:

Molding compounds: Alpha-cellulose-filled urea- and melamine-formaldehyde are noted for their durability, wide color range, electrical properties, and hard surfaces in appliance housings, buttons, dinnerware, wiring devices, and closures.

Adhesives: Excellent strength and light color for plywood and furniture gluing.

Textile resins: Employed to give added crease and wrinkle resistance for cloth.

Paper-treating resins: Impart added wet strength and folding endurance to all types of paper products contacting moisture.

Laminating resins: For the surface of decorative laminates, melamine resins provide smooth, hard surfaces, interesting decorative possibilities, and also exceptional durability.

Coating resins: When used in conjunction with alkyd resins, the amino resins produce durable, colorful, hard-surfaced enamels for appliances and cars.

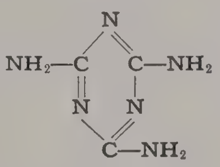
Foundry resins: For dimensionally precise sand cores and shell molds and cores.

Chemistry

An amino resin is formed as the result of a chemical reaction between one of several amino chemicals and aldehydes under carefully controlled conditions of mol ratio, time, temperature, and pH.

Urea, NH_2-CO-NH_2, is the amide of carbamic acid. It is a white crystalline material produced by reacting carbon dioxide and ammonia in autoclaves at 135 to 195° C. and 70 to 230 atmospheres.

Melamine is the amide of cyanuric acid (see formula below). It is a white crystalline compound resulting from the elevated temperature polymerization of cyanamide obtained from calcium cyanamide.



Formaldehyde, HCHO, is manufactured by the catalytic oxidation of methanol vapor. It is a gas, but is usually sold, transported, and used either in an aqueous solution of 37% formaldehyde (called formalin), or in a solid polymeric state. Small amounts of ethanol and formic acid arising from the manufacturing process are impurities in the commercial solution.

Because resin condensations are affected by the presence of ethanol and formic acid, it is customary to specify the composition of formaldehyde solutions within extremely close limits.

Intermediates, obtained from a partial reaction of urea and formaldehyde, are employed by certain resin manufacturers because these materials require less water in the solution than formalin for shipment and storage. Furthermore, they can be pumped directly from the storage tank to the reactor without the necessity of maintaining the separate storage facilities necessary for formalin. Intermediates include dimethylol urea and partially reacted urea-formaldehyde where adjustments in mol ratio can be made by the addition of urea to the solution.

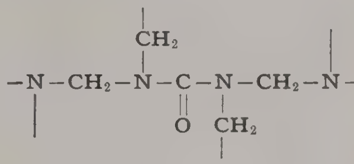
Urea resins: In the production of urea-formaldehyde resins, methylol ureas are formed as indicated by these formulas:

$$NH_2-CO-NH_2+HCHO \rightarrow NH_2-CO-NH-CH_2OH$$

$$NH_2-CO-NH_2+2HCHO \rightarrow CO(NH-CH_2OH)_2$$

Two mols of formaldehyde may react with one mol of urea as indicated, but in actual practice the mol ratio is varied depending upon the commercial application.

The methylol ureas condense under slightly acidic conditions with liberation of water to produce sirups. The sirups are used in much the same form as produced for some applications such as adhesive solutions, or as basic materials for compounding, as is the case with molding compounds. The mechanism of the condensation is not fully established and possibly varies somewhat, but there is evidence of the formation of three-dimensional structures through methylene cross-linkages:



$$-\underset{|}{N}-CH_2-\overset{\overset{|}{CH_2}}{\overset{|}{N}}-\underset{\underset{O}{\|}}{C}-\underset{\underset{|}{CH_2}}{\underset{|}{N}}-CH_2-\overset{|}{N}-$$

In the preparation of resins for surface coatings, the dimethylol compounds are reacted with alcohols in the presence of acids to form alkoxy compounds. These compounds condense with liberation of part of the combined alcohol to form resinous products soluble in organic solvents.

The basic resinous materials can take the form of clear, water-white sirups or dry white powders. The powders are usually soluble in water. Conversion to the insoluble and infusible stage occurs in the presence of acids or materials which react with formaldehyde to produce acidity. Heat is usually used in commercial applications to promote the cure of the resin. However, catalysts have been developed that make room-temperature curing practical in some cases, such as adhesives.

Melamine resins: Melamine reacts with up to 6 mols of for-

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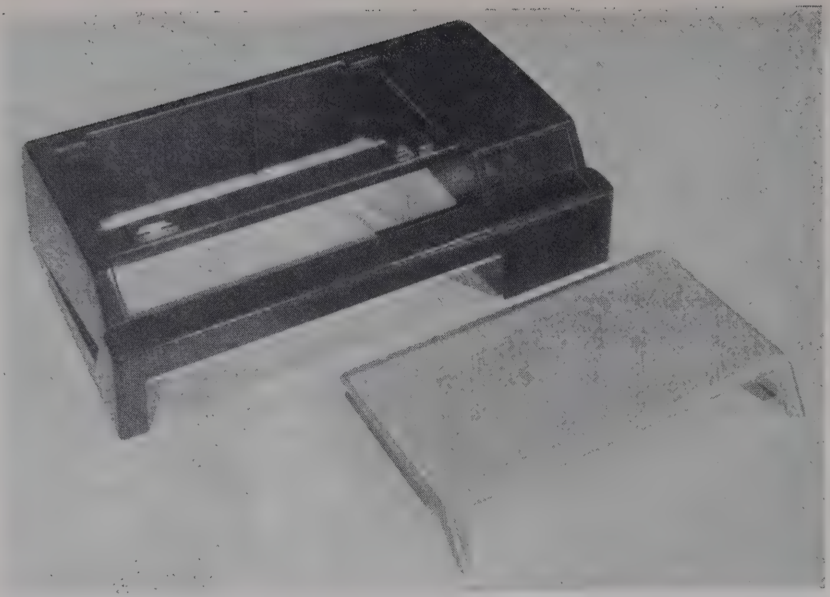
*Asst. Supervisor, Technical Service Laboratory, Plastics and Coal Chemicals Div., Allied Chemical Corp., 40 Rector St., New York, N.Y.

References were prepared by the editors.



RUGGED HOUSING molded of melamine for office photocopier replaces stainless steel, offers cost and weight savings. (Chicago Molded Products)

maldehyde to form methylol compounds. The mechanisms by which the methylol compounds condense to resinous products are probably similar to those involved in the condensation of methylol ureas. The triazine rings are probably cross-linked into three-dimensional structures by methylene groups.

In general, products based upon melamine-formaldehyde resins are found to be more resistant to heat and water than those based on urea-formaldehyde.

Molding compounds

Alpha-cellulose-filled urea-formaldehyde and melamine-formaldehyde molding compounds are well-known for their durability, wide range of colors, electrical properties, resistance to common solvents, very hard surfaces, and utility in lighting applications.

For a number of industrial uses, mineral and glass fiber fillers are used further to enhance the electrical properties and strength of melamine compounds. Urea compounds, such as the new wood-filled urea[1], are also made with wood flour filler. Although the color range of wood-filled materials is somewhat limited, it is an economical material that offers advantages in applications such as wiring devices and closures because of its electrical properties, solvent resistance, and color fastness.

Alpha-cellulose-filled materials are produced by thoroughly impregnating cellulose pulp with the aqueous urea- or melamine-formaldehyde resin sirup. The impregnated pulp is carefully dried under controlled conditions of heat and humidity and then ground to a fine powder.

Dyes or pigments, lubricants, and catalysts are added and the fine powder is densified. The densified product is then crushed so that the finished molding compound is in the form of granules. The molder can select a grade of molding material suitable for specific molding conditions because urea and melamine compounds are available in a wide range of plasticities from very soft to hard, and in a range of cure speeds.

Urea molding compounds: The color, strength, electrical properties, translucency, and surface finish of products molded of alpha-cellulose-filled urea compounds also have eye and sales appeal. They are used for items such as buttons, lighting fixtures, containers, closures for cosmetics, radio and television housings, clock cases, and knobs and handles.

In the case of wood-filled urea, the color of the filler limits color possibilities. However, the available colors are attractive and colorfast. The lower cost of these compounds makes them attractive for closures, wiring devices, and other end uses.

Parts molded of urea-formaldehyde compounds are odorless, tasteless, and chemically stable. They have a low burning rate or are self-extinguishing. Their resistance to organic solvents and weak acids and alkalies is good, and they are not affected by solutions used in the dry cleaning process. Their surfaces are very hard and durable and have good abrasion resistance. Molded pieces have excellent strength properties and electrical characteristics, including high arc resistance. While urea-formaldehyde parts can be exposed to hot water without softening, continuous contact with hot water may cause surface crazing.

The materials are usually molded within the temperature range of 275 to 325° F. and at pressures ranging from 2000 to 8000 p.s.i. Greater control must be exercised when molding urea than phenolics or melamine-formaldehyde compounds because it does not flow quite as readily and generally sets and cures slightly faster in the mold at a given temperature.

Melamine molding compounds: Moldings of alpha-cellulose melamine compounds are similar in appearance to those of the ureas. However, their greater resistance to heat, water, acids, and alkalies permits their use in more demanding applications such as tableware and other kitchen applications, hospital and nursery equipment, and a number of electrical parts. They withstand steam and autoclave sterilizing.

By far the most successful application and largest single outlet for melamine molding compounds is fine quality dinnerware. Decorative overlays, in a wide variety of designs and colors, are becoming very popular in this area. Unlike a decal, the overlay (a melamine-impregnated foil) actually becomes an integral part of the dinnerware so it will never wash or wear off. This same principle can be applied to other melamine or urea moldings such as clock faces, and appliance instruction panels.

The properties of melamine molding compounds vary widely according to the type of filler used. Wood flour, minerals such as asbestos, cotton fabric, and glass fibers are used for specialized applications. The choice of filler is dependent upon the balance of properties needed. Each filler is used to emphasize one or more specific properties but usually at a sacrifice in some other area. Wood flour is used for low cost and low specific gravity, cotton fabric for strength and low specific gravity, mineral fillers for improved electrical properties and heat resistance, and glass fibers for strength.

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[1] Allied Chemical Corp.

Adhesives

Urea formaldehyde resin adhesives are widely used in the manufacture of plywood, assembly gluing by woodworking firms, the furniture industry, the manufacture of flush-type doors, and the manufacture of particle board. Their advantages include good bonding properties, light color, excellent working qualities, ease of storing, and resistance to water and fungi. The adhesives are available as both liquids and powders, often with a variety of hardeners, so that they can be cured at temperatures ranging from room temperature up to 250° F. at varying cure speeds. High-frequency, electrical, and steam-heated devices are often used to accelerate cure. Cost reductions can be effected in applications that do not require high water-resistance by using soft wheat flour extenders. Urea adhesives can be fortified with resorcinol or melamine resins for use in applications requiring resistance to boiling water. Craze-resistant products are available that permit glue lines up to 0.02 in. thick in assembly gluing.

The newest volume application of urea adhesives is in the manufacture of particle boards used largely as core stock. Horizontal extruding machines can be used to form board of any desired length. Approximately a 65% solids adhesive solution is used in an amount to provide approximately 7.5 lb. of adhesive solids for each 100 lb. of wood particles which are used.

Although melamine resins can produce excellent bonds between a variety of materials, they are usually employed commercially as fortifiers for urea-formaldehyde adhesives. Melamine-urea types cannot be cold-set.

Textile resins

Low-molecular-weight urea-formaldehyde condensation products are useful for the impregnation of cotton and rayon textile fabrics to develop improved crease resistance. The cloth is impregnated with the resin, containing an appropriate catalyst. The resin is cured by heating the cloth at temperatures ranging usually from 200 to 250° F. Other types, usually of higher molecular weight, are employed in various stiffening processes.

Melamine-formaldehyde resins are employed in the treatment of wool, cotton, rayon, and other fabrics to impart shrink resistance, wrinkle resistance, water and stain repellency, and fire retardance. Generally, the melamine resin is applied to the fabric from a water solution. The fabric is then dried at a temperature high enough to cure the resin, and finally washed out.

Paper treating

Both urea- and melamine-formaldehyde condensation products are used to impart wet strength to paper for such consumer items as facial tissues, toweling, butcher wrap, and agricultural crate liners. The condensation products are modified to give cationic resin molecules that are attracted to the negatively charged paper fibers. The resin is usually added to the beater of the paper machine and it cures as the paper is dried. In addition to improving the wet strength severalfold, addition of these condensation products also somewhat improves the dry strength.

Laminating resins

Melamine laminating resins have enjoyed their greatest acceptance in the production of hard, durable, and washable decorative laminates for tabletops and similar applications. In the process, paper is impregnated with the resin solution and then dried. Several sheets of the impregnated paper can then be laminated in a platen press and cured for 15 to 30 min. at temperatures of 290 to 320° F. and pressures from 1000 to 2000 p.s.i. The sheets are also frequently employed as overlays for phenolic laminates.

Surface coatings

Both alkylated urea- and melamine-formaldehyde products are used with alkyd resins in the production of hard, durable baking enamels for refrigerators, automobiles, and kitchen and hospital furnishings. Resins of both types promote hardness of the enamel film with resultant mar resistance, resistance to soap, water, and mild acids, and excellent color retention. The melamine resins impart greater color retention at elevated temperatures and also provide improved mar and water resistance.

References

Consult the Subject Index for additional information concerning urea and melamine resins. For information on compression molding, see p. 631. See also the Adhesives, Coatings, Foamed Plastics, Laminates, and Plastics Properties Charts for information on properties and trade designations. For sources of amino resins, see Directory Index, p. 1078.

"Why not wood-flour-filled urea?" MODERN PLASTICS *35,* 115 (May 1958).

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Alkyd molding compounds

By J. T. Long*

Materials classified as alkyd molding compounds are based upon polyester resins, but they contain no highly volatile monomer. As a result, they usually can be transported, stored, and handled in the same manner as conventional thermosetting compounds. Arc and heat resistance, dielectric qualities and dimensional stability are other features.

Alkyd molding compounds can be divided into three types, classified by physical form before molding. These differences extend to the selection of filler and thus to the mechanical strength of each as well as the molding method to be used.

Granular types

Mineral or modified mineral fillers can be used to compound these free-flowing granular materials. Designed for high speed, fully automatic, or semi-automatic molding operations, contacts may be molded-in or inserted in a separate operation.

One of the major electronic applications for granular alkyd compounds is vacuum tube bases. The high dry insulation resistance of the material is particularly useful in special tube bases where the electrical leakage between pins must be kept at a minimum. Other uses for granular-type alkyd include automobile ignition systems, where retention of good dielectric characteristics at relatively high temperatures is a factor, radio and television components, transformer boards, and small switchgear.

Putty types

Putty-like materials are available for the encapsulation of resistors, capacitors, coils, transformers, and other small electronic devices where delicate inserts are to be molded within a protective shell. Usually, this alkyd form is extruded into ribbons prior to the molding process.

For many applications, the coefficient of linear thermal expansion of these alkyds is found similar to that of popular wire types, minimizing the change in dielectric performance before and after encapsulation.

Glass-reinforced types

Fibrous glass and other fibrous fillers are used in alkyd compounds for the molding of larger, heavy-duty parts where a combination of high strength, superior dimensional stability, good electrical properties, and heat resistance is required. They can be readily plunger or compression molded.

This alkyd type found initial success in defense equipment applications, where its high impact strength permitted parts molded of it to operate effectively under the shock conditions caused by gunfire. Commercial applications now include computer components, circuit breakers, signal light and fuse holders, motor end bells, rocker rings, blower housings, and various types of switchgear parts.

Alkyds in general

All alkyds are characterized in their molding behavior by at least three very significant features:

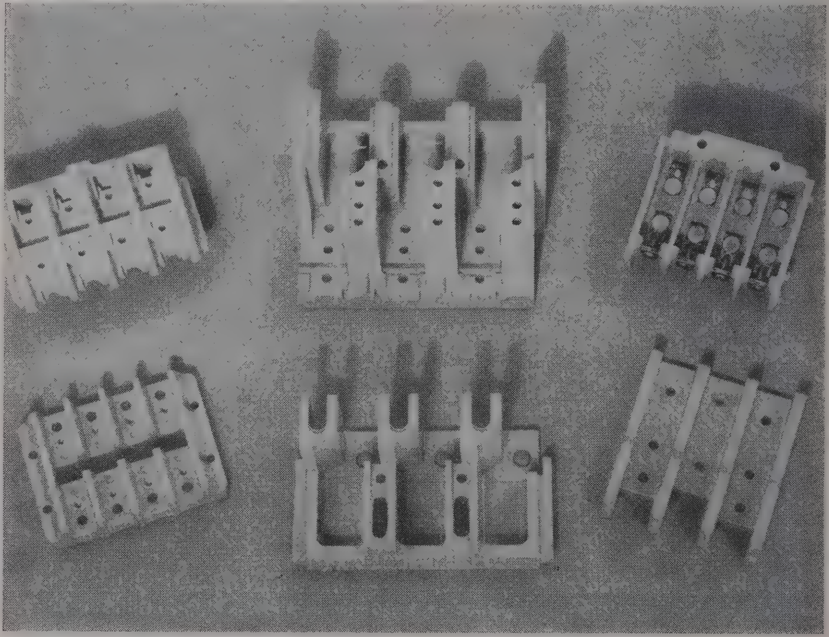
1) No liberation of volatiles during the cure.

2) Extremely free flow of the resin binder.

3) Fast cure at molding temperatures.

As a result of this behavior, a straight mold close without "breathes" is used. Free initial flow indicates the use of positive or semi-positive molds rather than the flash types. Complete cure can be effected at recommended molding temperatures in periods as short as 15 sec. for small parts with thin cross-sections; molding pressures can be as low as 500 p.s.i. for general-purpose material, up to 2,000 p.s.i. for impact grades. Typical molding temperature is 300° F.

ALKYD GRANULAR MOLDING COMPOUNDS, with mineral filler, are used for power control components, below, for high arc resistance, excellent electrical properties, good dimensional stability. (Photo, Allied)



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*Tech. Service Dept., Allied Chemical Corp., Plastics and Coal Chemicals Div., Toledo, Ohio.

Properties of Three Types of Alkyd Molding Compounds

Properties	*A.S.T.M. Test Method*	*Granular*	*Putty*	*Glass-fiber reinforced*
Molding properties				
Bulk factor	D392-38	1.85-2.05	>1	9-11
Mold temp., °F.	—	270-330	270-330	270-330
Molding pressure, p.s.i.	—	1000-1500	400-800	1500-2000
Mold shrinkage (cold piece from cold mold), in./in.	—	0.004-0.007	0.004-0.008	0.001-0.004
Properties of molded piece				
Physical				
Specific gravity	D792-50	2.17-2.20	2.05-2.15	2.02-2.10
Water absorption, 24 hr. @ 23° C., %	D570-57T	0.05-0.08	0.10-0.15	0.07-0.10
Heat resistance, max., °F.				
Long periods	—	275	250	300
Limited periods	—	300	300	350
Short periods	—	325	325	400
Heat distortion temp., 264 p.s.i., °F.	D648-56	350-400	350-400	>400
Coefficient of linear thermal expansion/°F.	D696-44	10-30$\times10^{-6}$	10-30$\times10^{-6}$	10-30$\times10^{-6}$
Thermal conductivity, g-cal/(sec.) (cm.^{2}) (°C./cm.)	—	15-25$\times10^{-4}$	15-25$\times10^{-4}$	8-12$\times10^{-4}$
Flammability (self-extinguishing?)	D635-56T	Yes	Yes	Yes
Mechanical				
Impact strength, Izod ft.-lb./in. of notch	D256-56	0.30-0.35	0.25-0.35	8-12
Compressive strength, p.s.i.	D695-54	16,000-20,000	20,000-25,000	24,000-30,000
Flexural strength, p.s.i.	D790-49T	6,000-9,000	8,000-11,000	12,000-17,000
Tensile strength, p.s.i.	D651-48	3,000-4,000	4,000-5,000	5,000-9,000
Modulus of elasticity, p.s.i.	D790-58T	2.1-2.6$\times10^{6}$	2.0-2.7$\times10^{6}$	2.0-2.5$\times10^{6}$
Barcol hardness	—	60-70	60-70	70-80
Electrical				
Arc resistance, sec.	D495-58T	180 plus	180 plus	180 plus
Dielectric constant	D156-54T			
60 cycles		5.7-6.2	5.4-5.9	5.2-6.0
1 megacycle		4.7-5.0	4.5-4.7	4.5-5.0
Dissipation factor	D150-54T			
60 cycles		0.040-0.050	0.030-0.045	0.020-0.030
1 megacycle		0.017-0.020	0.016-0.022	0.015-0.022
Dielectric strength, v./mil	D149-55T			
Short time		350-400	350-400	350-400
Step-by-step		300-350	300-350	300-350

Cellulosics

Development of cellulose nitrate, oldest of the synthetic plastics, dates back to the work of Braconnot in France, 1833. Schoenbein, Germany, 1845, and Parkes, England, 1855-65, also experimented with cellulose nitrate; but John Wesley Hyatt, United States, is generally credited with being the first to work successfully with this material as a plastic mass rather than in solution. In 1869 he and his brother took out a patent for making solid collodion (Celluloid) which was the pioneer material for many processes and applications used in the plastics industry.

Meanwhile, in an effort to discover a less flammable material, research conducted by Schützenberger and Cross and Bevan (1894) led toward the development of cellulose acetate. Preparation of a plastic from cellulose acetate was first mentioned in U. S. patent literature in 1903.[1]

As early as 1912, cellulose acetate found an outlet in photographic film. In World War I, it was employed in dopes for airfoil coverings. Later, a process was developed for making cellulose acetate filament which could be woven into fabric.[2] Cellulose acetate sheets, rods, and tubes appeared on the U. S. market in 1927. This was followed by the appearance of cellulose acetate molding powders in 1929.

Research on treatment of cellulose with higher aliphatic acids resulted in a U. S. patent for the manufacture of cellulose acetate butyrate, issued to Clarke and Malm in 1932. The material appeared on the market at that time for use in protective coatings. The molding composition followed in 1938.

Among the various cellulose esters, cellulose propionate is the most recent plastic to come into commercial use.

The possibility of using a cellulose ether as an industrially useful product was proposed in 1912 by Leuchs in Germany, Lilienfeld in Austria, and Dreyfus in France. Lilienfeld was granted a U. S. patent[3] in 1917 for use of ethyl cellulose in a plastic composition. In 1935 and 1937, respectively, two of the current manufacturers[4] undertook commercial production of this material.

Other cellulose ethers have also proved commercially useful; among these are methyl cellulose, carboxymethyl cellulose, and hydroxyethyl cellulose.

The cellulosics are prepared by various treatments of carefully purified cotton linters or wood cellulose having a high alpha-cellulose content. The cellulose molecule is composed of as many as 3000 glucosidic units. Each unit provides three hydroxyl groups for esterification. Controlling factors in the preparation of the various cellulose esters and ethers are the condition of the cellulose, the kind and relative amounts of ingredients used, and the time, temperature, and agitation of reaction.

Preparation of cellulosics

Cellulose nitrate: Cellulose nitrate is prepared by treating properly conditioned cellulose with a mixture of nitric and sulfuric acids. Spent acid is drained off by centrifuging. The nitrated material is given prolonged treatment with boiling water, bleached, washed repeatedly, and subjected to a dehydrating operation by which, under hydraulic pressure, most of the water is replaced by alcohol.

Cellulose acetate: Preparation of cellulose acetate is accomplished by treating cellulose with acetic acid and acetic anhydride in the presence of a catalyst such as sulfuric acid. Cellulose triacetate of about 62.5% combined acetic acid content is formed by the reaction. This is soluble in the treating acids, forming a heavy dope. Water is added to partially hydrolyze or deacetylate the cellulose triacetate. Cellulose acetate is then precipitated in water, washed, and dried.

Cellulose acetate butyrate: To prepare cellulose acetate butyrate, the cellulose is treated with a mixture of acetic and butyric acids and anhydrides, the amount of each ingredient depending upon the properties which it is desirable to have in the final product.

Cellulose propionate: Similarly, the reaction of propionic acid and anhydride on cellulose in the presence of a catalyst yields cellulose propionate.

Ethyl cellulose: Sodium cellulose is produced by the action of a strong alkali, such as sodium hydroxide, on cellulose. This is subsequently acted upon by ethylating agents, such as ethyl chloride or sulfate, which place the ethyl groups on the cellulose molecule. Ethyl cellulose thus formed is first washed and then purified.

Carboxymethyl cellulose: Carboxymethyl cellulose (cellulose glycolate) is composed of a carboxylic acid bound to the cellulose molecule by an ether linkage. Upon treatment with a fairly strong acid, the sodium salt is converted to the free acid which is insoluble in water. In some cases other salts may be useful; the ammonium salt, on heating, loses ammonia and is thus converted to the free acid. The addition of aluminum, iron, or other heavy metal ions converts the sodium salt to insoluble compounds. The cellulose derivative is precipitated from solution by ferric chloride, ferrous sulfate, stannous chloride, aluminum sulfate, or basic lead acetate. Barium nitrate produces a thixotropic gel.

Hydroxyethyl cellulose: When ethylene oxide is reacted with cellulose, a caustic-soluble hydroxyethyl cellulose is first produced. As additional hydroxyethyl groups are attached, the cellulose derivative becomes more and more water sensitive, until water solubility is reached. Metallic ions, acids, or alkalies cannot be employed to precipitate

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Sections on cellulose acetate prepared by Celanese Corp. of America; cellulose acetate butyrate by Eastman Chemical Products, Inc.; cellulose propionate by Celanese Corp. of America; ethyl cellulose by Dow Chemical Co.; hydroxyethyl cellulose by American Viscose Corp.

[1] U. S. Patent 738,533 to A. Eichengrün and T. Becker, 1903.

[2] Developed by Celanese Corp. of America.

References were prepared by the editors.

[3] U. S. Patent 1,217,027.

[4] Hercules Powder Co., The Dow Chemical Co.

hydroxyethyl cellulose from the aqueous solution.

Regenerated cellulose (cellophane): For the preparation of regenerated cellulose, sheets of sulfite wood are steeped in a carefully controlled solution of sodium hydroxide, resulting in a product known as sodium or alkali cellulose. Excess liquor is removed, and the alkali cellulose sheets are shredded and aged. Treatment with carbon disulfide follows, producing cellulose xanthate. This, in turn, is mixed with dilute sodium hydroxide solution to yield a uniform colloidal suspension, or viscose, which is aged and filtered. Regeneration is accomplished by extruding the viscose, in sheet form, into an acid coagulating bath which reacts with the viscose solution to form cellulose, sodium sulfate, and carbon disulfide.

Cellulose nitrate

Compounding and processing: Several grades are available, differing in nitrogen content as well as in the degree of viscosity.

Complete esterification provides a nitrogen content of 14.16 percent. Cellulose nitrate used in explosives contains approximately 13%, that employed in lacquers and photographic film about 12%, and that in plastics about 11 percent. Although the chief difference among the various grades is their rate of combustion, solubility as well as compatibility with plasticizers are also variable factors that have to be considered.

Camphor is the standard plasticizer for cellulose nitrate, although small admixtures of other materials are also used. Alcohol-wet cellulose nitrate is colloided in masticating mixtures with the plasticizers and solvents, and strained under hydraulic pressure while in a soft condition. The material can be colored while being worked in the mixer or during the subsequent rolling operation, when some of the solvent has been evaporated.

Slabs of the material can be block-pressed and skived, or the mass containing a suitable proportion of solvent may be wet-extruded into tubes, rods, or sheeting.

General characteristics: Cellulose nitrate is the toughest of all thermoplastics. This quality, together with ease of fabrication, are the chief advantages of the material. Other desirable properties are dimensional stability, resilience, and low water absorption.

Chief disadvantage of the material is its flammability. Plasticizers containing chlorine and phosphate as fire retardants have been employed, but these tend to reduce the strength of the resulting plastic. Another disadvantage of the material is its tendency to discolor and become brittle under the effects of sunlight.

Cellulose nitrate is not adaptable for compression or injection molding because of its sensitivity to heat. However, it is readily formed into hollow articles by application of air or liquid pressure between heated sheets, expanding them to the shape of a retaining mold. By other methods of fabrication, sheets, rods, and tubes are converted into many items of decorative and functional value, such as personal accessories, toilet articles, and various types of industrial pieces.

Cellulose acetate

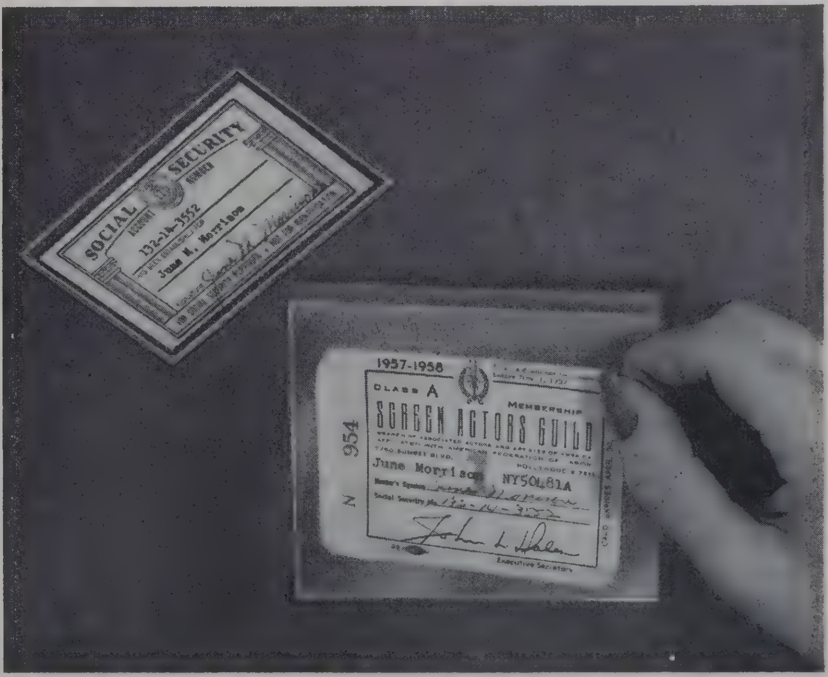
Compounding and processing: Cellulose acetate molding compositions are made from cellulose acetate flake, plasticizers, pigments, and dyes. Mixing is carried out on heated compounding rolls, in an extruder, or in a Banbury-type mechanical mixer. Processing temperatures are in the 350 to 500° F. range. Plasticizers are normally simple organic esters, liquids of high boiling point and low vapor pressure, added in amounts of 10 to 70 parts per 100 parts of cellulose acetate. The plasticizer employed is dependent upon the properties desired in the finished composition.

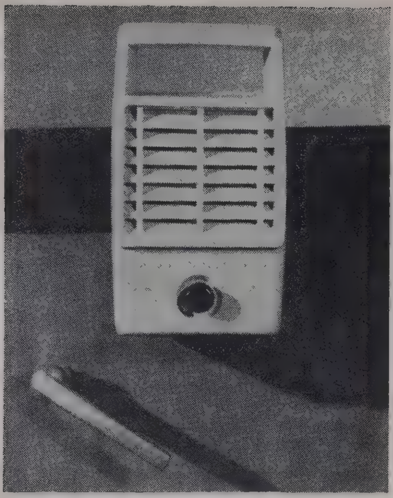
General characteristics: Cellulose acetate plastics are notable for their outstanding toughness and high impact strength. They are stable at room temperatures, with good resistance to discoloration or deterioration when exposed to sunlight. However, long-range exposure to outside weathering is not recommended. Materials can be produced over a wide range of rich lustrous colors, including translucents, transparents, and special color effects. Cellulose acetate is a good electrical insulator. The clear material transmits a high percentage of ultra-violet light.

Available in many different types, cellulose acetate is adaptable to a wide application range. Properties are dependent to a large degree on the flow type selected.

Present-day uses of cellulose

CLEAR CELLULOSE ACETATE film, adhesive-coated for do-it-yourself laminating, is tough and will not discolor. (Photo, Celanese)





OUTDOOR movie speaker molded of cellulose propionate will withstand rough handling and weather exposure. (Photo, Celanese)

acetate have been further broadened by the increasing trend towards formulating for specific end uses. Selection of the proper flake, combined with suitable plasticizers, yields compositions with the characteristics important to specific applications. The important properties that can be "built into" cellulose acetate include flame resistance, resistance to blushing, improved dimensional stability, reduced plasticizer migration, and resistance to specific chemicals, e.g., dichlorobenzene.

Applications: Large-volume markets for cellulose acetate are toys, beads, cutlery handles, knobs, electrical parts, and housings for small-motored electrical appliances. In sheet form, cellulose acetate is widely used as a packaging material, electric insulation, and tape. The largest volume end-use is for photographic film. Vacuum formed sheeting is growing in the fabrication of displays, custom packaging, and for small household and personal products.

Another large-volume application for acetate is ladies' shoe heels. The molded acetate heels are claimed to cost from 2 to 4¢ less than wooden heels with lacquer applied and are characterized by resilience and toughness. Consumption of acetate for heels was estimated at about 425,000 lb. a month for 1959.

During 1959 there has been a greater demand for fire-resistant cellulose acetate formulations in many housing applications. There is also a steady increase in the use of extruded and cast cellulose acetate film for produce wrapping. New formulations in clear, transparent extruded and cast film have been offered for special applications requiring protection from ultra-violet light. These materials contain special ultra-violet absorbing agents and have been found valuable for produce wrapping, wrapping of polyurethane sponges, and, in the thicker gages, for store window shades.

There is also a special cast film for producing a crackle or wrinkled finish on glass-polyester laminate sheets. It is used as a separating medium when the polyester sheets are made. The film also finds use as a separator sheet in the polishing of vinyls and is used to prevent blocking when these sheets are shipped.

The use of cellulose acetate film in sound recording and computer tapes is continuing to increase satisfactorily.

Cellulose acetate butyrate

Compounding and processing: Cellulose acetate butyrate molding compositions may be prepared by the same methods as those mentioned for cellulose acetate. The characteristics of the mixed ester are quite different from those of cellulose acetate, however, and result in compatability with a greater variety of other compounds. The plasticizers used with cellulose acetate butyrate have much higher boiling points than those used with cellulose acetate and not nearly as much plasticizer is required by the mixed ester as by the acetate. Cellulose acetate butyrate requires less plasticizer for a given flow than does any other commercially available cellulose ester.

Cellulose acetate butyrate is dissolved or softened by a wider range of solvents than is cellulose acetate, resulting in ease of cementing and lacquering.

Cellulose acetate butyrate plastics compositions are usually processed by injection molding or extrusion, although compression and transfer molding techniques may also be used. It has been used successfully in blow molding operations. Special formulations suitable for roller coating, melt coating, and lacquers are available. Sheets are widely used in vacuum forming operations.

During the past two years, major improvements have been made in the color and stability of cellulose acetate butyrate plastics. It has always been possible to granulate sprue and runner scrap, incomplete shots, and rejected pieces for re-use, providing practically 100% utility of the material. The improvements make it even less likely that such re-use will result in noticeable discoloration. It is still suggested, however, that clean reground material be blended with virgin material to avoid excessive remolding of the same material.

For good parts, cellulose acetate butyrate plastics formulations must be kept free from contamination by other plastics, particularly polystyrene. The only other plastics material with which cellulose acetate butyrate may be mixed is cellulose acetate propionate; even this is not possible with all formulas and flows.

General characteristics: Cellulose acetate butyrate moldings are characterized by high impact strength, toughness, light weight, and good resiliency. They are of uniform texture and have a high surface luster. The material is available in colors ranging from crystal clear to opaque in almost any desired color and shade, as well as variegations or mottles, pearlescents, and metallic effects. The dielectric strength is high and the heat conductivity is low. Special essences can be added to cellulose acetate butyrate to give a pleasant positive odor to molded pieces.

Cellulose acetate butyrate has considerably greater dimensional stability than does cellulose acetate. This is partly due to the fact that cellulose acetate butyrate is less hygroscopic in nature, absorbing upon immersion about the same amount of water as does cellulose nitrate and only about half as much as does cellulose acetate. Cellulose acetate butyrate accepts plasticizers which are much higher boiling than those used with cellulose acetate, and requires much less total plasticizer to reach a given flow. These two factors combine to result in less loss of plasticizer during heating, leaching, or weathering, with a resultant smaller change in shape.

Plasticizer permanence also contributes to the excellent weatherability which is attainable with cellulose acetate butyrate. Pieces properly molded from special outdoor formulas can be expected to last five years fully exposed to the elements in any part of the United States.

Underwriters' Laboratories, Inc., has classified cellulose acetate butyrate as "Slow Burning." Its report says, in part: "The fire hazard of this product in use and storage is judged to be small, being somewhat less than would be presented by common newsprint paper in the same form and quantity."

Applications: Molded or extruded parts which are to be vacuum metalized are suitable applications for cellulose acetate butyrate, due to the low plasticizer content and the low vapor pressure of the plasticizer at ordinary temperatures. Molded cellulose acetate butyrate photoflash reflectors vacuum metalized with a mirrorlike metallic coating are proving far superior to satin-finish aluminum reflectors. It is reported that metalized cellulose acetate butyrate reflectors give about 50% more illumination than the older aluminum reflectors. The toughness and resilience of the plastics eliminate denting of the reflector if it is dropped.

Cellulose acetate butyrate sheets are widely used for vacuum forming and contribute excellent formability and fast cycle to the operations. These qualities, plus light weight, toughness, resilience, and weather resistance in the outdoor type formulas, combine to make the material useful for both outdoor and indoor signs. The same qualities have resulted in wide usage of extruded sheeting as covering material for greenhouses. The heat-insulating qualities of cellulose acetate butyrate and its ability to resist the impact of hailstones also contribute to this and similar applications.

Another application involving continuous outdoor exposure is in treeguards extruded from cellulose acetate butyrate. These are used on telephone wires to protect the wires from abrasion by tree branches. The life expectancy of the guards is said to be better than ten years.

DRIVE-IN RESTAURANT ordering system has vacuum formed butyrate menu sign and speaker-microphone housing. Impact and weather-resistant, the units are attractive and easily maintained. (Photo, Eastman)

Cellulose acetate butyrate is also being used outdoors in the form of extruded large-diameter pipe to replace the glass globes which protect street lights from weather; the impact strength of the material provides good protection against vandalism.

One other outdoor use of cellulose acetate butyrate is in automobile taillight and back-up lenses. Both clear and red lenses resist crazing when exposed to spillage of high octane gasoline and will withstand the elements for several years without serious changes in dimensions or color.

Cellulose acetate butyrate sheeting is widely used for blister and skin packaging because of its excellent clarity, light weight, toughness, ease of forming, and brilliant luster. A recently developed process of skin packaging with cellulose acetate butyrate without a backing board should increase the use of this plastic in the field.

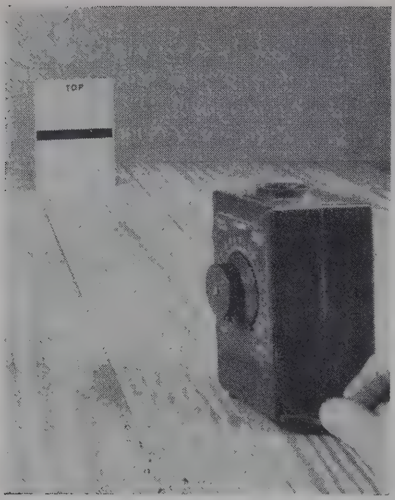
Typical applications of molded cellulose acetate butyrate include: screwdriver and other tool handles, photographic reels, housings, steering wheels, automobile armrests, telephones, football helmets and face protectors, knobs, cutlery handles, pistol grips, business machine keys, toothbrush handles, fish net floats, fishing lures, hearing aid parts, optical frames, and ladies' shoe heels.

Typical applications of extruded cellulose acetate butyrate are: pipe for irrigation and salt water disposal, gas service lines, electrical conduit for telephone and power cables, small diameter tubing, film for packaging, sheeting for vacuum forming and other uses, profile shapes for decorative molding trim, window channels, pneumatic tubes, pneumatic tube carriers, explosion-vent windowpanes, and storm windows.

Cellulose propionate

Compounding and processing: Cellulose propionate requires less than half the plasticizer needed to produce cellulose acetate plastics of comparable flexural strength. It is compatible with a considerably larger number of plasticizers; compounds can therefore be plasticized and modified to produce moldings of a great variety of properties.

Cellulose propionate is best suited to injection molding and extrusion. It has excellent flow



STRONG and inexpensive ethyl cellulose housing protects parts of precision leveling instrument. (Photo, Hopkins Mfg. Co.)

characteristics which provide molding temperatures over a range of 80° F. Unless inserts, machine limitations, heavy cross-sections, or ribbings are involved, it has a shorter cycle than other cellulosics. In all except the hardest compositions there is no trace of skin or lamination.

General characteristics: Cellulose propionate is an unusually stable cellulose ester, emitting no odor of propionic acid either during molding or in the finished piece. Retention of plasticizer is excellent. Weatherability characteristics are superior to cellulose acetate while being equivalent or, in some instances, superior to other cellulosic molding materials. Although not miscible with cellulose acetate, ethyl cellulose, or resinous plastics such as polystyrene, cellulose propionate is compatible with cellulose acetate butyrate.

Among the cellulosics, cellulose propionate is close to ethyl cellulose in toughness and shock resistance. High shock resistance is maintained without sacrifice of other desirable characteristics; articles produced from cellulose propionate can be printed and lacquered without fear of tackiness. Weld lines are almost unnoticeable, and weld strength is high, as indicated by both impact and tensile strength tests. Surface finish of injection molded pieces is brilliant and so lustrous and free from smudges that many parts require no buffing or similar finishing operation.

Applications: Current markets for cellulose propionate are automotive parts, pens and pencils, telephone housings, ladies' shoe heels, toys, transistor radio and television parts, toothbrushes, and sunglass frames.

Ethyl cellulose

Compounding and processing: Ethyl cellulose is available as molding and extrusion powders, cast sheet and film, and flake. Cast sheets are now available in widths up to 40 in., an increase of 10 in. over the widest cast sheet previously available. The natural color of the polymer is amber, but it is available in a full range of transparent, translucent, and opaque colors.

Ethyl cellulose compounds can be processed on standard injection molding machines, extruders, and compression molding presses. The resulting pieces, sheets, or profiles are characterized by high surface gloss and lack of surface imperfections.

Ethyl cellulose sheet lends itself readily to vacuum forming operations without the necessity of special equipment. The temperature range required for forming is critical if premium quality parts are to be obtained.

General characteristics: The general characteristics of ethyl cellulose can be controlled to some extent in manufacture. If the degree of ethylation is held in the 48 to 49.5% range, a product is obtained with higher compatibility with various modifying agents. This grade of material, generally used in coating applications, has low softening temperatures, wide solubility, and good water resistance. If ethylation is held at 46 to 48%, the resulting material is found to be tougher, and to possess better low-temperature properties. This grade of polymer is used as the base for molding powders.

The viscosity and over-all properties can also be controlled by varying the modifying agents used in compounding. Compatibility with a wide range of modifiers including esters, natural resins, resin acids and esters, tars, and waxes allows ethyl cellulose to be formulated to meet specific requirements.

Ethyl cellulose has the lowest density of the commercial cellulosic plastics. The density varies from 1.07 to 1.18, depending greatly on the way in which the base polymer is prepared and modified. This feature gives ethyl cellulose some advantage when volume-costs are compared with weight-costs of other cellulosics.

Ethyl cellulose has superior electrical properties, excellent dimensional stability, and low water-absorption rates.

Applications: The introduction of high-impact and high heat-resistant formulations has further extended the possible use of the material. Football helmets, bowling pin bases, and floor sweeper parts are among the applications where the ability of ethyl cellulose to withstand heavy abuse is used to advantage.

Ethyl cellulose is also used in flashlight cases, furniture trim, refrigerator breaker strips, luggage, military applications, and various extruded tubings.

Carboxymethyl cellulose

Compounding and processing: This cellulose derivative is compatible in varying proportions with many water-soluble plasticizers, natural gums, and other film formers. Highly viscous, stable, aqueous solutions can be obtained which, upon evaporation, leave colorless, tough, transparent films that are unaffected by most organic solvents, oils, and greases.

General characteristics: Carboxymethyl cellulose is available in three viscosity types: low, medium, and high. These products can be rapidly dissolved in water-ethanol mixtures, when the alcohol does not exceed 50% of the mixture. Films cast from sodium carboxymethyl cellulose solutions and painted with solutions of aluminum sulfate, barium nitrate, stannous chloride, basic lead acetate, ferric chloride, or ferrous sulfate are insoluble in water. The solutions of sodium carboxymethyl cellulose are commonly utilized for their thickening properties as viscosity control agents in the preparation of latex emulsions, as emulsifying agents in the preparation of oil-in-water solutions, and as bases for ointments, boiler compounds, oil-drilling muds, and insecticides. Other applications for this cellulose derivative are as coatings for carton board used in the manufacture of containers which must be greaseproof.

Hydroxyethyl cellulose

These ethers of cellulose are made by reacting alkali cellulose with ethylene oxide. The properties and characteristics of the ethers will depend upon: 1) the number of hydroxyethyl groups introduced into the cellulose (Degree of Substitution or D. S.); and 2) the degree of polymerization or chain length of the basic cellulose.

Two distinct classes of ethers can be made: those which are soluble in aqueous sodium hydroxide solutions and insoluble in water (D. S. about 0.3 to 2.5) and those which are soluble in water (D. S. over 2.5). The size of the cellulose molecule will also affect the solubility, and since the hydroxyethyl group contains an active hydrogen atom, long branch chains can be built up. Ethers soluble in organic solvents have been made.

The ethers which are soluble in aqueous sodium hyroxide solutions can be regenerated by neutralization of the alkali. The alkali-soluble ethers can be used as textile finishes by padding on the solution and then neutralization. The type of finish is controlled by the molecular size which is measured by the viscosity of the solution. Ethers can be made to give textiles a stiff, crisp finish or a soft hand. The finish is permanent and abrasion resistance is improved. Paper can be coated in a similar way. Pigments can be bound for dyeing or printing, e.g., finishing and printing of scrim for camouflage cloth.

The alkaline solutions can be extruded into an acid bath through a wide slit to form a transparent film, or through an orifice to form a filament.

The water-soluble ethers can also be prepared with different molecular sizes and viscosities so that on evaporation of the water, a good film, a weak film, or a powder will deposit. The water-soluble film or deposit can be made water-resistant by cross-linking with formaldehyde, glyoxal, and a urea- or melamine-formaldehyde resin.

BUTYRATE SAFETY cover for electric meters prevents breakage during installation, offers insulation against short circuits. (Eastman)

Like a regenerated cellulose film, the ether films can be made more flexible by adding certain humectants, such as the polyhydric alcohols. They are compatible with most water-soluble gums.

Unlike the alkyl cellulose ethers which are insoluble in hot water, the hydroxyalkyl cellulose ethers are soluble in both hot and cold water.

Uses for the water-soluble ethers include yarn sizing and textile finishing. Dimensional stability of a rayon fabric can be obtained with these materials. They are also used as a protective colloid in latex polymerization, as thickening agents in cosmetics, have been suggested for use in food products, and investigated by the paper industry.

These ethers can be supplied as dry powders or in fibrous form.

Cellophane

Compounding and processing: The film, prepared by regeneration of cellulose from viscose solution, is immersed in successive purification baths, and finally in dilute solutions of glycerol or other softening agents which may also flameproof the film. The film is then dried to the desired moisture content and sheeted or slit into small rolls. If moistureproof film is desired, a coating composition is applied in very thin layers on both sides of the cellophane.

General characteristics: Commercially, cellophane is the most widely available low-cost film. It is easily fabricated and especially adaptable to high-speed automatic machinery and to various printing techniques.

Electrical properties of the material permit its use in industrial electrical equipment. The film serves not only as insulation but also as a protection against oil and grease. It is employed in low-pressure molding of laminates to prevent the material from sticking to the mold. Laminated to itself or to other materials, it is used in packaging.

References

Consult the Subject Index for additional information on cellulosic plastics. For injection molding, see p. 594; for extrusion, see p. 656; for fabricating, see p. 778. See also the Adhesives, Coatings, Films, Foamed Plastics, and Plastics Properties Charts for information on properties and trade names. For sources of cellulosics, see Directory Index, p. 1078.

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Cold molded organic plastics

Cold molded plastics were introduced in the United States near the beginning of this century by Emile Hemming. They differ basically from the more common plastics molding materials in that they must be baked after removal from the mold to oxidize and polymerize the binder materials. Cold molded plastics fall into two main categories based on the types of binders employed—organic, and inorganic or refractory. The organic materials are divided into two types—bituminous (asphaltic binder) and synthetic resin (phenolic binder). Inorganic cold molded materials are discussed in the chapter on Inorganic Plastics. Asbestos is a common filler for all types and it provides high-heat resistance characteristics.

Bituminous binder: This binder is composed of asphalt, gilsonite, stearine pitch, or vegetable pitch blended with oils, such as linseed, castor, and tung, to form a varnish-like resin. This resin is reduced to proper viscosity with solvents, mixed with asbestos fiber, seasoned, ground, and finally screened.

Phenolic binder: Phenolic resin is treated with a solvent to produce a solution of the proper viscosity; then it is mixed with asbestos fiber, seasoned, ground, and screened to proper size.

Since the cold molded plastics can be squeezed into shape by pressure alone, production is rapid—as high as 3500 to 4000 pieces/hour with certain types of equipment. Baking, required to set the piece after shaping, can be accomplished for a large number of pieces simultaneously, and usually consumes one to several days depending upon the size and cross-section of the piece. On small thin pieces the baking cycle may be considerably under 24 hr.; heavier cross-sections may require up to 72 hours. When organic binders are used, the temperature starts at approximately 175° F. and is raised in hourly increments of 10 to 20 degrees to approximately 450° F.

Ease of fabrication varies according to the type and percentage of abrasive components. Mold wear is also affected by abrasive content. In general, cold molded articles tolerate metal inserts.

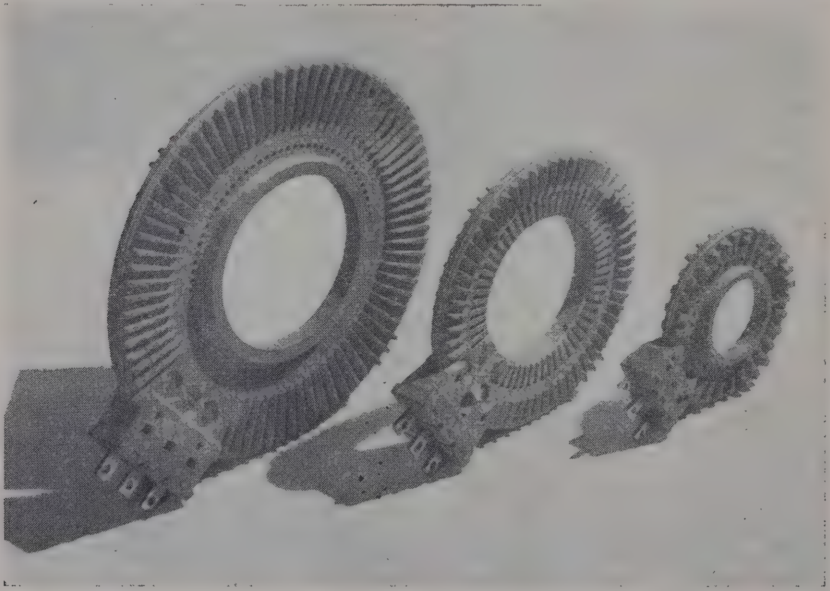
General characteristics: Cold molded articles usually lack the surface smoothness, gloss, and appearance that characterize hot molded items. Dimensional differences are relatively large. Through modification of compounds and advances in processing, strides have been successfully made in stabilizing and improving these characteristics.

With some of the newer types of compounds, dimensional variation and design limitations are not so critical. Tensile strength has been improved. Baking is not necessary unless increased tensile strength is essential, or accelerated setting is desired. Color range has been greatly broadened. Mold wear has been reduced. New free-flowing powders are adaptable to rotary presses, and small pieces can be pressed up to 300 per minute.

Phenolic compositions surpass bituminous types in both mechanical and electrical properties, and can be made with a finish that is at least comparable to that obtained in hot molding. Both types exhibit resistance to high heat and most alkalies and solvents, and are nontoxic and relatively low in cost. Most of these compositions are molded on hydraulic presses supplied with oil pressure ranging from 2000 to 4000 p.s.i. The somewhat soft pieces are seasoned on perforated trays at room temperature before baking.

Applications: Cold molded organic plastics find applications in many electrical products.

RESISTOR ELEMENT supports are illustrative of high-temperature-resisting parts of complex shape obtainable with cold-molded organic plastics. (Photo, Rostone Corp.)



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Consult Subject Index for additional information on cold molded organic plastics. See also the Plastics Properties Chart for information on properties and trade designations. For sources of cold molded plastics, see Directory Index, p. 1078.

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Coumarone-indene, petroleum, and polyterpene resins

By P. O. Powers*

There are many varieties of low molecular weight hydrocarbon resins. They are, however, all characterized by relatively low softening points (ball and ring), usually 100 to 110° C.; however, some varieties may run as high as 160° C. They are also characterized by low molecular weights —often around 1000—although some varieties may run as high as 25,000 while the softer grades may be considerably below 1000.

Traditionally these resins are prepared from byproducts of huge scale operations and often the starting materials contain more than a single resin former. There is a noticeable trend to use purer materials to reinforce feed stocks or to form polymers or copolymers with improved properties. Also, the raw materials are often *further* refined before converting them to resins.

The first and still an important raw material for hydrocarbon resins is found in certain fractions of coal tar distillates. Coumarone and indene are the principal resin formers in these streams and the resins are traditionally called by that name, but cyclopentadiene, dicyclopentadiene, and styrene and its homologs are also used to form resins. The styrene in coal tar, however, is not purified to the degree required to produce polystyrene for injection molding. As consumption of thermoplastic hydrocarbon resins expanded, the demand outran the supply of coke oven and gas tar crudes and other sources of resin formers had to be sought. Petroleum distillate from cracking operations was the answer.

The petroleum resins vary somewhat in composition and in character; their aromatic content varies widely—some have no aromatic structure whatsoever while others have an appreciable content of aromatic structure and are used where coumarone-indene resins were formerly employed.

Polyterpene resins extend the field of low molecular weight resins and offer properties that make them unique in this field. They are more expensive than petroleum resins and must justify their use by their special properties.

Coumarone-indene resins

Coumarone-indene resins are available in many varieties varying from soft plasticizing resins to hard brittle resins of 140° C. softening point (ball-and-ring). Colors of these resins measured on the coal tar scale may be pale yellow of color 1 to quite dark brown. Solubility of these resins is excellent in aromatic hydrocarbons, but in mineral spirits or other aliphatic solvents the higher melting resins may be only partly soluble and require the addition of 20 to 30% aromatic hydrocarbon to bring them into solution. Resins of controlled solubility are available for particular applications.

Resins are manufactured by treating the unsaturated fractions with an acid-type catalyst, conditions varying somewhat with the type of resin desired. Also, streams may be blended to give the desired finished resin. After polymerization is complete, the catalyst must be entirely washed out of the resin solution and neutralized. The solvents are then stripped from the washed solution by steam, or in vacuum, or by a combination of steam and vacuum.

The low-molecular-weight polystyrene resins should be considered with the coumarone-indene resins, first, since some of these resins are derived from styrene or its homologs from coal tar, and second, because their properties and applications are more closely related to the coal tar hydrocarbon resins than to the higher-molecular-weight resins used for molding.

They are, however, considerably tougher and more viscous than the coumarone-indene resins of equal softening point. In addition, the polystyrene resins from synthetic raw materials are considerably better in color and color stability. The resins are offered in softening points from 5 to 150° C. ball-and-ring. They are used in many of the same applications as coumarone-indene resins, particularly where color stability and film strength are required, e.g., coatings and adhesives.

Applications: Coumarone-indene resins often are used as processing aids, extenders, or plasticizers with more elastic and tougher resins or rubber. Their addition inevitably improves water resistance and often helps adhesion. They are also used in coatings, particularly in concrete sealers, flat wall paints, wall primers, and aluminum vehicles.

Coumarone-indene resins are widely used as reinforcing resins with synthetic rubber, and the softer grades are employed as processing aids and tackifiers. The harder grades have a reinforcing effect, particularly in non-black stocks with styrene-butadiene synthetic rubber. This effect is more pronounced with the less soluble resins.

Asphalt tile is one of the major outlets for coumarone-indene resins. Resins of controlled solubility are produced especially for this field. Scrap polystyrene molding grade has been widely used with these resins to extend and reinforce them, and has necessitated development of special plasticizers for use in resin blends.

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* Pennsylvania Industrial Chemical Corp., 120 State St., Clairton, Pa.
References were prepared by the editors.

Petroleum resins

Production of petroleum resins has increased greatly in the past few years, while the production of coumarone-indene resin has increased to a much lesser degree. Since the available raw material supply for coal tar hydrocarbon resins is not expanding, the resin production must be expected to remain substantially constant. In the case of petroleum resins, not only has the total production increased, but new types of petroleum resins have been offered and the resins have been made available in solution, in solid, and in emulsion form.

Light-colored petroleum resins are soluble in mineral spirits in all proportions. Resins are available in solid and flaked form at melting points of 100° C. and higher. Petroleum resin emulsions of good color are available in all emulsion form, both of the anionic and non-ionic types, adapted for use in coatings and paper size, and for other industrial uses.

Certain petroleum resins possess a moderate iodine value and are susceptible to reaction with oxygen. Stabilized varieties are available which do not oxidize even with prolonged aging. Petroleum resins, in general, have better color stability than do coumarone-indene resins. The iodine value of hydrocarbon resins is considerably higher than their actual unsaturation would indicate. Also, conditions for determination of the iodine value must be vigorously standardized to give consistent values.

Applications: Petroleum resins of pale color are available with anionic, cationic, and non-ionic emulsifier systems. Anionic emulsions have been popular for reinforcing latex paints and are used with styrene-butadiene, polyvinyl acetate, and acrylate paint systems. The addition of the emulsion imparts improved adhesion and often better scrubbability. Emulsions are also available for the sizing of paper and may be used in conjunction with, or in place of, rosin or fortified rosin sizes. The cationic and non-ionic emulsions are relatively new and are employed where water resistance and resin reinforcement are desired.

Petroleum resins find wide use in rubber compounding. The softer resins are used as plasticizers, while the harder resins are used to impart stiffness to synthetic rubbers. A notable improvement in tensile strength and cut growth is accomplished by the incorporation of such resins in the formulation.

Pale petroleum resins can be used with the drying oils to produce water-resistant varnishes. Gloss and adhesion are also improved by their use. Color stability of petroleum resins is considerably better than that of the coal tar resins. Petroleum resins find extensive applications in adhesives and saturants. They are also widely used to modify other resins. Petroleum resins are readily soluble in paraffinic and chlorinated hydrocarbons, but are generally insoluble in the lower alcohols or ketones.

Petroleum resins are also finding application with paper, particularly as a hot-melt saturant for corrugated. A 70° C. softening point petroleum resin results in much-improved water resistance, and also considerably stiffens the resulting board. The resin penetrates the board on heating. In addition, petroleum resins are finding other uses as a waterproofing and reinforcing saturant in fiber and particle boards. The resin may be applied either in emulsion form or as a hot-melt.

Terpene resins

Polyterpene resins are firmly established in the adhesives and coatings fields, and wherever a readily soluble hard resin of good color is required. In the last year the polyterpene resins have been in rather short supply due to the greatly increased demand.

Commercial polyterpene resins are lower in density than the coal tar or most petroleum resins. Recent improvements in manufacturing methods have resulted in better and lighter-colored resins. Grades melting from 10 to 135° C. (ball-and-ring) are produced. The harder varieties are available in flake form. They are composed in their entirety of hydrocarbon.

Applications: The terpene resins are used with drying oils in varnishes. Such varnishes made with tung oil have exceptional heat resistance. The vehicles containing terpene resins have good color retention.

Polyterpene resins are compatible with many waxes and may be used in emulsion waxes. They are compatible with polybutenes, chlorinated and cyclized rubbers, and long-oil alkyds. They are used in concrete curing compounds where a pale solution is required. Since polyterpenes blend readily with natural and synthetic rubbers, they are used in rubber compounding adhesives. Since these resins are nontoxic, they can be used in food packaging. Light color, tack, and stability make them popular in pressure-sensitive adhesives.

Terpene polymers show fine compatibility with polyethylene and are very useful with the more fusible polyethylenes.

References

Consult the Subject Index for additional information concerning coumarone-indene, polyterpene, and petroleum resins. See also the Adhesives and Coatings Charts for information on properties and trade designations. For sources of these resins, see Directory Index, p. 1078.

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Epoxy resins

By Frank E. Pschorr*

In both properties and variety of end uses, epoxies are one of the most remarkable groups of plastics now available. Their ability to "stick" to almost any substrate—most plastics, metal, glass, and wood—is unsurpassed. Epoxies have outstanding strength, chemical resistance, water resistance, electrical properties, and heat stability. The main fields of use include adhesives, coatings, laminates, tooling, casting, electrical potting and encapsulation, body "solders", surfacing compounds, repair kits, and vinyl stabilizers.

Epoxies are manufactured chiefly by reacting epichlorohydrin with bisphenol A. Epoxidized novolacs are also appearing on the market. One other recent method of manufacture is the peracetic acid process.[1]

Epoxy resins were developed from basic research carried on in Switzerland. The first resins were produced in the laboratory in 1938, but it was several years after World War II before commercial production began. Since that time manufacture and sales of epoxy resins have grown tremendously. From nearly zero output in 1949, production grew to around 28 million lb. in 1958. Market studies predict that sales of epoxies will be around 45 million lb. by 1960.

Basic chemistry

Epoxy resins (also called epi-, epoxide, and ethoxyline resins), are the condensation products of epichlorohydrin with diphenols, such as bisphenol A, and have the structure shown in Fig. 1, below.

The resins, in the illustrated uncured state, are thermoplastic and range from low viscosity liquids ($n=0$) to high melting point brittle solids ($n=10$). An epoxy resin may be defined as a polyether containing a highly reactive epoxy or oxirane group at each terminal, separated by an alternating aromatic and aliphatic system containing hydroxyl groups.

The epoxide group behaves as a highly unsaturated system and, therefore, can react by addition with a wide variety of materials, especially those containing polar (active hydrogen) groups. Hence, except for being much more reactive, the epoxy group acts in a manner very similar to that of an olefin. However, in spite of their reactivity, they are not subject to air inhibition or catalysis and, therefore, offer exceptionally long storage lives and consistent curing or hardening characteristics.

Epoxies harden at room or elevated temperatures by reaction with a curing agent, usually an amide, acid, or another resin.

The reaction, when using an amine, involves the opening of the oxirane ring to form an alcohol, without the formation of byproducts. This leaves the hydroxyl group available for further reaction. Cross-linking is achieved when di-, tri-, and other polyamines are employed.

When acids are used, generally in the form of anhydrides, the reaction probably occurs in two stages. Thus, both functional groups take part in the reaction and for each anhydride molecule consumed, a hydroxyl group is re-formed and one epoxy group is consumed. Hence, anhydride curing yields a more fully cross-linked, tri-dimensional structure than is possible with amine-type curing agents.

In addition to these hardening systems, epoxies will polymerize with each other in the presence of suitable activators. It is quite apparent, therefore, that very many cross-linking possibilities are presented.

Since the hardener and resin actually react and the curing agent is molecularly combined, the properties of the final product are greatly influenced by the chemical structure of the hardener chosen. The reaction or hardening may therefore properly be termed polymetathesis, although only one product is formed.

Adhesives

Adhesives based on epoxy resins are used for bonding a wide variety of materials—plastics, metal, ceramics, glass, vulcanized rubber, cork, leather, textiles, and so on.

The epoxy-based adhesives range from fluid to viscous, paste-like, and solid resins with corresponding liquid and paste-like hardeners. A few, but not many, contain solvents. When the products are supplied in solid or in powder form, the resin and hardener are already mixed. As a rule, they are applied to preheated surfaces, or else to cold surfaces which are then heated. For liquid or paste forms, the hardener is generally added at room temperature immediately before use. The mixture is then applied to the surfaces to be bonded. With adhesives containing a solvent, the latter must be evaporated by pre-drying after application.

In the same way that conventional bonding methods (such as riveting, welding, or soldering) impose special constructional re-

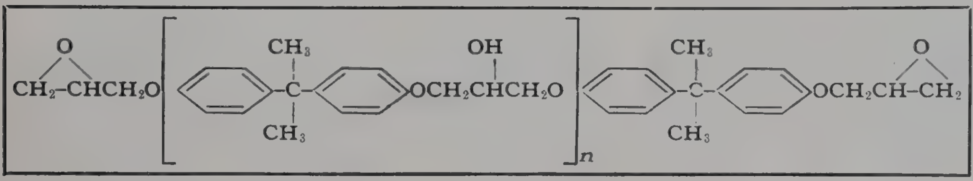

FIG. 1: Structure of epoxy resin in the uncured state. See discussion in text above

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* Mgr., Structural Resins Lab., Ciba Products Corp., Fair Lawn, N. J.

[1] Developed by Union Carbide Corp.

References and Recent Developments were prepared by the editors.

Water-white transparent epoxy resin (*Maraglas,* Marblette Corp.) is suitable for casting, laminating, and bonding . . . castings report to have light transmission of 90%, about the same as commercial glass . . . operate continuously at 212° F. without effect on transparency . . . company also supplies room-curing epoxy pastes—*Maraset 641* (aluminum-filled), *642* (white unfilled), and *643* (steel-filled) . . . all are putty-like, with high strength, chemical resistance, adherence to metal, glass, wood, plastics, masonry . . . where high heat resistance is required, steel-filled paste can be cured at 300 to 400° F.

Safety pavement based on an epoxy resin (*Guardkote,* Shell Chemical Corp.) resists skidding even when wet . . . stops cars in one-half to three-quarters of the distance required on concrete.

Concrete floor coating and patching compound (*Epoxylite #3454,* The Epoxylite Corp.) adheres tenaciously . . . hardens overnight at room temperature . . . provides complete resistance to moisture, acids, alkalies, oils and greases, detergents, and alcohols.

Organophosphorous modifier (*Mod-Epox,* Monsanto Chemical Co., Organic Chemicals Div.) for liquid epoxy resin systems imparts low initial viscosity . . . accelerates rate of cure . . . maintains or improves physical and electrical properties while cutting cost by 20% and more.

4,4′-diaminodiphenyl sulfone (*Eporal,* Roussel Corp.), used for decades in leprosy treatment, now found to be excellent curing agent for epoxy resins.

Three solid epoxy resins (*D.E.R. 661, 664,* and *667,* Dow Chemical Co.) have superior purity . . . enable processors to use dissolved resin without filtering. Having extreme clarity, they are recommended for coatings.

Epoxy extender (*NX 3157,* Irvington Chemical Div., Minnesota Mining & Mfg. Co.) chemically bonds with the resin at low temperatures . . . when mixed 50:50, it cuts material costs by 25% without impairing properties. Further savings result from decrease in resin viscosity.

Three new epoxy resins (Union Carbide Corp.) are derived from petrochemical products based on natural gas materials. *Epoxide-201* flows like water . . . is easy to pour into complex molds . . . will not discolor with exposure to light. *Vinylcyclohexene dioxide,* an intermediate, can be polymerized to a three-dimensional resin . . . also can form condensation resins with dicarboxylic acids. *Dicyclopentadiene dioxide* can be formed into an epoxy with anhydride hardeners and polyol initiators . . . used in grinding wheels, brake linings, and in dry laminates.

New epoxy adhesives (*Cepox 400,* Chemical Development Corp.) combine high impact strength, excellent adhesive properties, and flexibility.

One-part 100% epoxy adhesive (*Isobond 321,* Isochem Resins Corp.) offers properties of the most tenacious epoxy bonding material . . . eliminates mixing, weighing, and metering of two-part adhesives . . . excellent electrical insulation properties.

Anhydride curing agent (Hexahydrophthalic anhydride or methyl Nadic anhydride, National Aniline Div., Allied Chemical Corp.) gives epoxy potting compound with higher heat distortion temperature (up to 209° C.) . . . better electrical characteristics . . . easier workability than amine-cured epoxies . . . longer pot life ideal for mass production setups.

Anti-foam agent (*Hysol M-453,* Houghton Laboratories, Inc.), reduces surface tension of liquid epoxy casting systems, is sprayed in a fine mist above the resin surface and permitted to settle gently . . . allows air bubbles to break easily . . . eliminates surface bubbles and pinholes in cured castings.

One-component epoxy-based adhesive (*Resiweld #105,* H. B. Fuller Co.) forms bonds with strengths of over 5000 p.s.i. with aluminum and steel . . . surfaces to be joined do not require clamping during care. . . . Bonds are resistant to water, temperature changes, most chemicals.

Decorative flooring (*Epoxy-Terrazo,* Ciba Products Corp.) applied in ⅛ in. thicknesses is epoxy-based with actual marble chips . . . gives high impact strength, adhesion to almost any sub-floor, light weight, and quick, economical installation.

In convenient liquid form, new hardener (*Araldite 957,* Ciba Products Corp.) yields the outstanding properties of solid aromatic amine/epoxy systems . . '. flexural deformation temperatures and chemical, electrical properties of the cured systems are equal or better than most solid aromatic amine systems.

quirements, bonding with epoxy resin-adhesives also requires that the components be designed so that the joints, as far as possible, are strained in the direction of the adhering surfaces.

Heat-curing adhesives are employed for bonding similar materials which have about the same co-efficients of thermal expansion. Materials sensitive to heat, ceramics, or other materials with very different coefficients of thermal expansion should be bonded with adhesives which cure at room temperature. Adhesives which are flexible in their cured state are particularly suitable.

Although curing can take place without pressure, the parts to be bonded should nevertheless be so fitted that the thickness of the resulting joint does not exceed 0.1 to 0.2 mm.; these joint thicknesses not only provide the greatest strengths, but the resin is also kept in place in the joint by its capillary strength. For thicker joints (up to approximately 5 mm.) pasty adhesives should be selected or else steps must be taken to see that the adhesive cannot exude from the joint.

Curing varies according to the adhesive employed and is effected either at room or slightly elevated temperatures, or at elevated temperatures only. The curing time can vary from days to hours or only minutes: the higher the temperature, the shorter the curing cycle. Mechanical strengths of joints made with heat-curing adhesives are generally higher than those bonded with adhesive which set at room temperature.

The cured epoxy resin in the joint is infusible, practically insoluble, and resistant to ageing. Because of its dielectric properties, it can be employed for certain insulating purposes in the electrical industry.

In many cases it is advantageous to use epoxy resin adhesives with a carrier material such as fibrous glass cloth. This is advisable, for example, when the coefficient of thermal expansion of the adhesive layer must be brought into line with that of the materials to be bonded, or when the joint must serve at the same time as a positive insulating layer between the parts.

A few examples of bonding with epoxy adhesives in various branches of industry include: *Metal construction*—Light metal window and door frames; metal letterboxes; sheet metal laminates; light metal photographic tripods; adjustable pipe and hose couplings for fire brigades; milk pails and other sheet metal containers. *Foundries and machine construction* — Components for durable metal forms; light metal gear housing components; diecast parts; packing of porous castings and joints; securing of threads. *Tool and grinding wheel industry*—Hard metal supports for cutting and measuring tools and centerless grinding machines; stamps for cutting tools. *Vehicle construction* — Doors, seats and luggage carriers; wall linings for railway coaches and buses, ships, and aircraft; supporting constructions and reinforcements; defrosting equipment for aircraft.

Casting

Epoxy casting resins and their hardeners are supplied either as liquids or solids at room temperature. Curing of the resin-hardener mixture is achieved either at room temperature or by heating, but no pressure need be applied in either case. No perceptible quantity of volatile substances is given off during cure, but the process is accompanied by the development of a varying amount of exothermic heat. Shrinkage during cure is very slight. Cured castings are infusible and isotropic. They are practically insensitive to water, weak acids, and alkalies, to many solvents, and also to atmospheric influences. If adhesion to mold parts, etc., is not desired, it must be prevented by means of release agents.

The viscosity and pot life of the resin-hardener mixtures can be varied to a considerable extent by the choice of resin and hardener, the operating temperature, the addition of fillers or, in certain cases, by adding accelerators. The viscosity may amount to only a few centipoises; the pot life can last only minutes or can be extended to days or months.

Before processing, the resins may be extended with various fillers such as quartz flour or sand, porcelain and chalk flour, kaolin, talcum, slate flour, certain metallic oxides, glass fibers, or ground graphite and metals. Such additives reduce production costs and at the same time alter the properties of the cured resin. These alterations can bring about a reduction of the exothermal reaction, still less shrinkage on curing, a smaller coefficient of linear thermal expansion, greater heat conductivity, increased compressive strength, lower impact flexural strength, and higher specific gravity. The quantity added varies according to the type and granular size of the filler; it may amount to as much as several times the weight of the resin.

Color of the resin, which is normally straw to yellow, may be varied as desired by the addition of suitable pigments.

Curing of epoxy casting resins occurs at room or at a slightly elevated temperature (20 to 100° C.; 68 to 212° F.) or at elevated temperatures only (100 to 200° C.; 212 to 392° F.), depending on the components used. The curing time may range from days to hours or only minutes; a higher temperature gives shorter curing time.

The possibility of processing pure or filled epoxy resins without pressure generally permits the casting of solid pieces in

EPOXY masonry coatings upgrade and add color to concrete building materials. (Photo, Production Paints & Coatings)

FLOOR-SURFACING compounds, epoxy based, are applied in thin layers by conventional trowelling techniques to provide good resistance to chemicals, impact, and moisture. (Photo, Protex-A-Cote)

molds, the manufacture of sizable work-pieces, and the embedding or bonding of sensitive elements. As solvent-free liquid products, they can also be used in vacuum for nonporous impregnation of coils or for filling the smallest cavities in metal castings.

Epoxy resin castings are used in numerous fields, such as: *Chemical industry*—Battery casings; centrifugal and membrane pumps; pipes for transport of liquids, pipe fittings such as friction valves, flange couplings, closings, etc.; casings and parts of membrane and flap valves; laboratory ware; abrasion-proof underwater slide bearings for centrifugal pumps, dye baths, etc. *Electrical industry*—High-voltage, low-current applications; telephone and high-frequency equipment, X-ray apparatus; electrical measuring instruments; electrical equipment for internal combustion engines; transformers; stators, rotors, and commutators; circuit breakers; cable closing sleeves and cable end stoppers. Within these areas will be found epoxies used for impregnating cores, transformer coils, capacitors, etc.

Laminating

Reinforcement materials, used singly or in combination with epoxies in the production of laminates include fibrous glass (in the form of woven fabric, mat, roving, and chopped fiber, paper, textile materials, asbestos, mica, metal foils, metal netting, etc.

Laminates made with epoxy resins are remarkable for their high mechanical and electrical resistance, the values of which are greatly influenced by the reinforcing material. These laminates are practically insensitive to the attacks of humidity, oil, various solvents, weak acids, and alkalies. They retain their properties within a temperature range from −60 to +110° C. (−76 to +230° F.) and, if resins which are particularly resistant to heat are used, to over 260° C. (500° F.).

The following methods may be employed: hand lay-up method, vacuum bag method, pressure bag method, matched-metal molding, casting and impregnating, or preforming.

Epoxy-fibrous glass laminates have assumed particular significance in the field of laminates inasmuch as epoxy resins adhere extremely well to glass fibers and there is hardly any shrinkage on curing. The mechanical strength of the laminates is accordingly high, especially under the influence of moisture, continuous loads, and vibration. They also exhibit high dimensional stability.

Epoxy laminating resins have proved their value in numerous spheres of application of which the following are examples: *Automobile and aircraft industries*—Models and fixtures, such as Keller models, checking and assembly fixtures, drill jigs, router jigs, and cutting, wrapping, and welding fixtures; aircraft noses, fuel tanks, floors, and partition walls; bodies and body components. *Plastics processing*—Molds for low-pressure molding of glass cloth or glass mat laminates with polyester or epoxy resins and for vacuum forming of thermoplastic sheets. *Boat construction*—All types of boats and coverings for wooden boat hulls. *Electrical industry*—Pipes and conduits; inserts for switch and quenching chambers; printed circuits. *Metals industry*—models; core boxes; apparatus parts; casings. *Miscellaneous*—Fishing rods; helmets.

Surface coatings

Epoxy resins for surface coatings include three general groups:

1) *Heat-curing resins,* intended for acid- and alkali-resistant coatings for drums, cans, and collapsible tubes; punching and deep-drawing coatings for the metal sheet industry; protective coatings for metal foils; enamels for corrosion protection of fittings and machinery; and primers for appliances.

2) *Ester resins* of the air-drying and nondrying types, used in manufacturing durable exterior coatings and primers with adhesion and resistance properties; enamels with very good color and gloss retention and excellent resistance to detergents. Used for washing machines, refrigerators, and gym floors.

3) *Room temperature curing resins* used in the manufacture of two-component coatings and compounds which cure at room temperature to very hard and highly flexible coatings with excellent chemical resistance. These are used for clear finishes for wood, brass, copper, nickel, and chromium; transparent colored lacquers for aluminum foil; pigmented coatings for machinery, apparatus, containers, and pipes exposed to highly corrosive environments; linings for concrete pipes and tanks; coatings for plastics; protective coatings for the electrical industry; rust-proofing primers;

and exterior finishes for waterproofing and decorating masonry, concrete, and cinder block.

The curing time of most of these coatings can be cut down to a few minutes by the use of elevated temperatures.

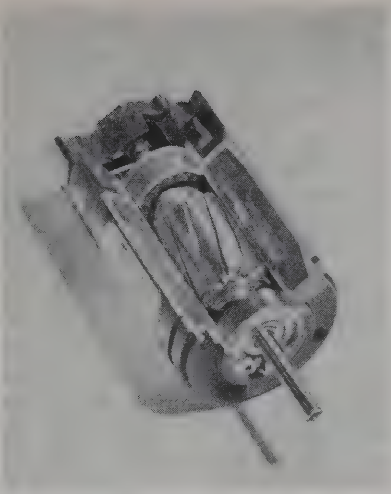
Highway surfacing

One of the biggest potentials for epoxies lies in road and highway building and repair. Many companies are presently conducting extensive development programs with test strips on bridges and roads. From these tests, the superiority of epoxy-based compounds is becoming increasingly evident. The test strips include several different specific uses: 1) Sealing membranes. 2) High-friction surfaces. 3) Cast traffic reflectors. 4) Adhesive films for repairs, for bonding new concrete to old concrete, in reflection strips and traffic bars, etc.

Epoxy systems are rarely used in pure forms for these applications since they are many times greater in adhesive strength and chemical resistance than the conventional construction materials with which they are combined. Instead, the resins are compounded with fillers, pigments, high-friction materials, and aggregate to produce mixtures which fit particular applications. The wide formulating latitude of epoxies permits them to be varied a great deal to suit many different end uses and application conditions. All of the compounds developed thus far are two-part systems, but mixing is usually on a simple basis, requiring one-to-one portions or just adding all the contents of one container to that of another.

Floor surfacing

Compounds based on epoxy resins for floor surfacing are another recent fast-growing innovation in the building field. These materials, based on liquid epoxy resins and curing agents mixed with various concrete aggregate, are supplied as three components which are mixed prior to application. The usual method of applying these materials consists of trowelling a layer about ¼ in. thick over old flooring or conventional concrete. Potential areas of application include sidewalks, warehouses, chemical plants, swimming pools, silo linings, and dairies and food processing plants.



ELECTRICAL components encapsulated in epoxy are protected from dirt, vibration, moisture, and chemicals. (Photo, Ciba)

Miscellaneous applications

Other fields of application include: auto body "solders"; repair kits; molding compounds; foams; and vinyl stabilizers.

Automotive body "solders" to replace toxic lead and tin solders adhere well, are light in weight, and can be handled by relatively unskilled workers.

Home repair kits come in a variety of sizes and forms, some with only a few ounces of resin and sufficient hardener for minor repairs, others with several pints of resin, mixing containers and fibrous glass fillers and cloth for more elaborate work. Kits for repairing auto fenders and bodies are also growing in popularity.

Premix molding compounds are being developed and perfected which can be handled with more ease and reliability than earlier epoxy materials. However, special mold release agents are still a necessity because of the high degree of adhesion of the epoxy resins. Usually, fillers and reinforcements are incorporated in these mixtures.

Foams manufactured from epoxies are sometimes used to encapsulate electrical components for insulation purposes. These foams are very low in density and adhere well to metal parts. The method of manufacture involves the addition of a suitable blowing or foaming agent. Gas is evolved simultaneous with the curing reaction to form a foam structure which conforms to the walls of the container or mold.

Epoxy resins make excellent stabilizers for vinyl-based plastics and coatings. Offering good resistance to both ultra-violet light and high temperatures, low-molecular-weight epoxies function synergistically by acting as hydrogen chloride acceptors.

References

Consult the Subject Index for additional information concerning epoxy resins. See also the Adhesives, Coatings, and Plastics Properties Charts for information on properties and trade designations. For sources of epoxies, see Directory Index, p. 1078.

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Ethylene polymers

Commercial polyethylenes are known as low-density (or conventional, since this was the first ethylene polymer plastic produced) in the density range up to 0.925, medium-density (0.926 to 0.940), and high-density (0.941 to 0.965).

More polyethylene is produced today than any other plastics material and its rate of growth is still increasing. By the end of 1956, annual consumption of conventional polyethylene passed 500 million lb. and in 1958 it was about 840 million lb. (virgin and *some* reprocessed). This figure also includes about 242 million lb. which were exported. If the high-density polyethylenes reach expected production, total annual domestic polyethylene consumption may reach 1 billion lb. by the end of 1959.

Polymerization

Basically, all polyethylenes are synthesized by the polymerization of ethylene molecules in the presence of suitable catalysts. Conventional low-density polyethylene (also known as branched polyethylene, high-pressure polyethylene, etc.) is synthesized at elevated temperatures and very high operating pressures (15,000 to 30,000 p.s.i.). Free radical catalysts such as peroxides and possibly other selected diluents are used. Medium-density polyethylenes can be manufactured in the same type of equipment used to produce low-density polyethylenes with the density being controlled by the proper selection of catalysts, chain transfer agents, and diluents. The stiff, high-density polyethylenes (also called linear polyethylenes, low-pressure polyethylenes, etc.) are made at lower synthesis pressures and temperatures, using coordination catalysts.

Although these are the three main classes of polyethylene, each constitutes a large family of different resins.

Fundamentally, a polyethylene molecule is made up of a long chain of carbon atoms, each with two hydrogen atoms attached. The molecule usually contains between 800 and 100,000 carbon atoms.

During the synthesis process, the active end of a growing molecule sometimes dislodges a hydrogen atom from the middle of another molecule, producing an active site which results in the growth of a long-chain branch at that point. As might be expected, a polyethylene containing a sizable proportion of such branched molecules exhibits different flow properties in the molten state than one of similar molecular weight without long-chain branching.

A second type of reaction which may occur during the synthesis process results in the formation of many short branches (1 to 4 carbon atoms in length) at irregular intervals along the main chain and the longer branches. These short branches are partially responsible for the great differences in solid-state properties which exist between the branched and linear types of polyethylene.

Crystallization

One of the properties of the type of hydrocarbon chain found in polyethylene is a tendency to crystallize. Crystallization is said to have occurred when a number of chains, lying in approximately parallel alignment, assume a more compact configuration, producing a small crystal or "crystallite." A single hydrocarbon chain or long branch may pass through several crystallites, with disordered or "amorphous" portions between.

Compared with the amorphous material, the crystalline material is harder and stiffer (because the closely parallel chains are bound together) and it is denser. The higher density in the crystallites is due to the "close-packing" of the resin chains in the crystalline lattice. X-ray measurements indicate a density of 1.00 for the crystallites. The density of the amorphous regions are not known with certainty since various types of measurements lead to figures ranging from 0.76 to 0.85.

In any resin, therefore, the relative percentages of crystalline and amorphous materials will determine the density of the whole resin. A completely (100%) crystalline resin would have a density of 1.00; a wholly amorphous resin in the vicinity of 0.80.

Melt index

The amount and types of branching, as well as the average molecular size, affect the flow properties of the molten polyethylene in a complicated manner. Originally, it was considered convenient to determine the molten viscosity under a set of rigidly specified conditions. The number of grams of molten polymer which will flow through a standard orifice at a standard temperature and pressure in a given time is called the melt index (MI) of the polymer. For polymers made by the same manufacturer and by the same process, the higher the melt index, the more fluid is the melt. However, two polymers of the same melt index produced by different processes will not necessarily perform in the same manner in extrusion and in molding operations. For this reason, the melt index determination is essentially useful only as a quality control test during polymer manufacture and does not serve as an exact correlatable variable with performance in extruders and molding machines.

Since melt index is generally considered to be a logarithmic function of molecular weight, it can be used as a rough estimate thereof and of those properties generally associated with molecular weight. Polymers with a high melt index have a lower molecular weight, lower softening point, lower stiffness, higher brittle temperature, etc. (Refer to A.S.T.M. MI designation, D-1238-52T.)

Molecular weight distribution

Unfortunately, it is sometimes observed that melt index is not necessarily a true indication of

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Text updated for this issue by technicians of Celanese Corp. of America, The Dow Chemical Co., E. I. du Pont de Nemours & Co., (Inc.), Eastman Chemical Products, Inc., W. R. Grace & Co., Hercules Powder Co., Phillips Chemical Co., Spencer Chemical Co., Union Carbide Plastics Co., and U. S. Industrial Chemicals Co.

Recent Developments and References were prepared by the editors.

Addition of high-density polyethylene (*Marlex,* Phillips Chemical Co.) to rubber gives greater reinforcement than either high styrene resin or conventional polyethylene. Initial studies indicate improvement in tensile strength and gas impermeability . . . higher resistance to solvents . . . improved dent- and scuff-resistance in floor tile . . . lower heat build-up.

A new series of polyethylenes (Marlex 5000), Phillips Chemical Co.) of 0.950 to 0.960 density offers excellent thermal and environmental stress-crack resistance . . . superior load-bearing characteristics without major sacrifice in stiffness or toughness. . . . It contains resins with melt indices ranging from 0.2 to 5.0.

Paper coating and film are suggested uses for high-density polyethylene resins (*Super Dylan,* Koppers Co.) with melt indices of 6 and 9 . . . they may be extruded or blown . . . give a better hot draw-down, greater clarity, faster output, easier handling.

Flexible pipe (*Carlon Hi-Mol,* Carlon Products Corp.) made from high-density polyethylene (Allied Chemical Corp., Semet-Solvay Petrochemical Div.) combines high resistance to stress cracking . . . chemical resistance . . . life expectancy comparable to PVC pipe . . . can handle corrosive fluids at low pressure under operating temperatures up to 150° F.

Slush molding polyethylene as a custom service (W. & F. Mfg. Co., Inc.) . . . is done in molds previously used for wax products.

New household food storage and service items (*Refrigerator-to-Tableware,* Idealware, Inc.), designed by Russel Wright . . . made of linear polyethylene (*Fortiflex,* Celanese) . . . possess physical properties required for food preparation and storage . . . have styling that permits them to double as tableware.

For extruding high-density polyethylene packaging film (*Super Dylan Type 6060F,* Koppers Co.), a water-quench method is suggested where clarity and gloss are of prime importance and where ease of opening packages is a necessity . . . chilled-roll casting where strengthwise balance is desired . . . blown extrusion for frozen or other "boiled-in-the-bag" foods.

Flame-retardant compounds of high-density polyethylene (*Grex,* W. R. Grace & Co.) are available in a variety of colors. Among first applications are television yokes, baby bottle warmers, heads for tanks containing nitrogen, oxygen, and acetylene. Two formulations are available: *C-1007* for products requiring higher impact strength; and *C-1008* for larger moldings where freer flow is necessary.

Eight polyethylene standard color concentrates (*Tenite,* Eastman Chemical Products, Inc.) offer molders an economical way to obtain thorough dispersion and consistent color . . . consist of high-concentration pigments predispersed in polyethylene-base material.

Polyethylene extrusion-coating resin (*Dow polyethylene 610M,* The Dow Chemical Co.), for paper, cellophane, and foil, has a melt index of 5. It exhibits excellent draw-down, resulting in lower coating weights and increased economy. Another Dow resin (*700C*) is used primarily for heavy coatings . . . has higher melt index.

For blending with conventional resins . . . a high-density polyethylene resin (*Fortiflex A-800,* Celanese Corp. of America) has a melt index of 8. Properties of products molded from this blend fall between the limits of the two types of PE used, depending on the percentage in the blend.

Grease-resistant coating is made up of low-molecular-weight polyethylene (*A-C,* Semet-Solvay Petrochemical Div.) combined with other polyethylenes . . . can be applied with a conventional reverse roll coater.

Flexible polyethylene pipe (made from *Alathon Super 25,* Du Pont) is claimed to have withstood long-term tests for strength that equal many high-density or linear resins without having their stiffness . . . can be coiled in 1500 ft. lengths and is offered for use in buildings subject to F.H.A. regulations.

Pipe made from a special formulation of high-density polyethylene (*Hi-fax 1700 E Pipe Black,* Hercules Powder Co.) is low in cost . . . has performed without failure for over three years . . . will pass the 1000-hr. tests required for conventional polyethylene of equivalent pressure range.

Polyethylene can be applied to steel by a new process (Tank Lining Corp.) developed expressly for lining tanks, pipe, and valves. . . after special preparation of the steel surface, the high-molecular-weight, high-density, low-pressure type polyethylene material is sprayed on the metal and then is heat treated to effect a permanent bond.

the ease of flow during processing. This fact stems from the non-Newtonian nature of molten polyethylene. In a Newtonian fluid, the amount of flow is always directly proportional to the stress applied. In other words, the viscosity is the same whether the stress is little or great. In the case of polyethylene, on the other hand, the greater the applied stress, the lower the viscosity becomes. The amount of departure from Newtonian behavior is greatly affected, in polyethylene, by the breadth of the *molecular weight distribution.* If two polyethylenes of the same melt index have different molecular weight distributions, the resin of narrower distribution will have the greater apparent viscosity at stresses above that applied in the melt index test. Conversely, the resin of broader distribution of molecular weights will have the higher apparent viscosity at very low shear stresses.

Low-molecular-weight materials

Inert low-molecular-weight polymers of ethylene are available in uniform cubes or powder form and in hot-melt or water-emulsifiable grades for use in paper coatings, and in paints, inks, and varnishes. More recently, blends of low-molecular weight polyethylene and high-molecular-weight polyethylene have proved to be the solution to some of the general molding problems encountered when using high-molecular-weight polyethylene alone. Flow problems and faulty color dispersions, for example, can sometimes be cured by the combination, but such blends can have detrimental effects on environmental stress cracking. High gloss and superior mold release are also easy to obtain when using these blends.

Slush molding of low-molecular-weight polyethylene is now possible with available formulas.

Selecting polyethylene

When determining the type of polyethylene to be used for a given job, the material can be defined by the values of three parameters: density, melt index, or molecular weight distribution. A more precise and fundamental definition would also include branching as well as average molecular weight.

1) *Density:* As the density increases: a) stiffness increases; b) yield strength increases; c) Graves tear strength increases; d) surface hardness increases; e) chemical resistance increases; f) Elmendorf tear strength decreases; g) Vicat softening temperature increases; h) permeability to liquids and gases increases; i) film toughness decreases; and j) flex life decreases.

2) *Melt index:* As the melt index is increased: a) melt fluidity increases (viscosity decreases); b) melt "drawability" increases; c) film coefficient of friction increases; d) tensile strength decreases (by about 10% in going from 0.2 to 5.0 melt index); e) Elmendorf tear strength decreases; f) resistance to environmental stress cracking decreases; g) low-temperature toughness decreases; h) Vicat softening temperature decreases (by about 10 to 15° F. with a change from 0.2 to 5.0 melt index); and i) impact strength decreases.

3) *Molecular weight distribution:* A decrease in the breadth of molecular weight distribution at constant average molecular weight or constant melt index has these effects: a) tensile strength increases[1]; b) film toughness increases; c) low-temperature toughness increases; d) Vicat softening temperature increases; e) resistance to environmental stress cracking increases; f) ease of processing at high shear stresses decreases; and g) impact strength increases.

After an initial selection is made on the basis of density, a further selection with regard to melt index is necessary. The degree to which the properties will be affected by a melt index change will depend on the density of the polymer. Examples of this are film coefficient of friction and Vicat softening temperature. With low-density polyethylene, the difference in the coefficient of friction of film prepared from commercially available polymers of various melt indices is readily measurable, whereas the differences in this property of the commercially available linear films is undetectable. The same is true for Vicat softening temperatures.

The effect on any one property due to a change in molecular weight distribution will also depend on the density of the polymer. Vicat softening temperature is again an example of this effect, varying noticeably with melt index for the low-density polyethylenes, and being constant for the commercially available linear resins.

LOW-DENSITY POLYETHYLENE

Ethylene was first directly polymerized to form polyethylene by Fawcett and Gibson in the late 1930's. They discovered that when ethylene was subjected to pressures of the order of 1000 to 2000 atmospheres and temperatures in excess of 100° C., in the presence of oxygen or peroxide catalysts, a solid polymer was formed. Most of the low-density polyethylene manufactured today is made by this basic process.

The properties of polyethylene resin depend on the chemical structure of the polymer molecules. The simplest structure which can be drawn for the polyethylene molecule is

$CH_3—CH_2CH_2CH_2CH_2—CH_3$

Evidence from infra-red spectra and other sources indicates that the chain is not linear and regular as shown but is interrupted by various irregularities. Small amounts of unsaturation are present, but the main type of irregularity is branching.

To appreciate the effect of branching, first consider straight chains without branching. Without branches to protrude and interfere, the chains have a good chance of lining up parallel with other chains. The result of the tendency to parallelization is a structure in which any one chain is somewhat curled, but all along the length it is parallel with other chains and close to them. When the possibility of parallel alignment of simple molecules of the polyethylene type exists, it is usually found that crystallization or

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[1] It is claimed by one manufacturer that the tensile yield point decreases with a decrease in breadth of molecular weight distribution. It should be recognized, however, that tensile strength and tensile yield point are not necessarily identical and that one can increase and the other decrease.

Polyethylene resins and their uses*

Manufacturers	Density	Melt index — average	Injection molding	Extrusion	Blow molding	Film	Wire coating	Cable jacketing	Coating	Hot melt	Pipe extrusion	Thermoforming sheet	Monofilaments	Trade Designations
Catalin Corp. of America														Catalin
	0.918	8.0	x											65-1
	0.918	22.0	x											65-2
	0.929	22.0	x											65-3
	0.924	22.0	x											65-4
	0.924	8.0	x											65-5
	0.924	5.0	x		x									65-6
	0.918	5.0	x		x									65-7
	0.924	3.0	x		x									65-8
	0.924	2.0			x									65-9
	0.917	2.8	x											65-10
	0.918	1.0	x											65-11
	0.929	22.0	x											65-13
	0.945	0.6	x	x	x	x								35-40
	0.947	0.2	x	x	x		x					x		35-50
	0.96	5.0	x			x								45-10
	0.96	0.7	x	x	x	x						x		45-20
	0.96	0.2		x	x							x		45-30
	0.96	2.0	x											45-40
	0.96	3.5	x											45-50
	0.95	0.4		x	x		x				x	x		45-60
	0.95	2.0	x											45-70
	0.95	5.0	x			x			x					45-80
	0.95	9.0	x			x			x					45-90
Celanese Corp. of America														Fortiflex
	0.96	5.0	x											A500
	0.96	2.5	x											A250
	0.96	0.7			x									A70
	0.95	0.2			x								x	B50-20
The Dow Chemical Co.														Dow P/E
	0.917	2.0				x								510E, 515E
	0.923	2.2				x								544E, 545E
	0.927	8.0				x								775G
	0.916	1.5	x											410M
	0.916	5.0	x											610M
	0.916	7.0	x											700M
	0.916	20.0	x											900M
	0.916	28.0	x											910M
	0.926	2.0	x	x										550E
	0.926	8.0	x											770M
	0.926	20.0	x											990M
	0.926	35.0	x											1000M
W. R. Grace & Co.														Grex
	0.96	0.2		x	x							x	x	60-002E
	0.96	0.7	x	x	x	x						x	x	60-007E
	0.96	2.0	x											60-020E
	0.96	3.0	x											60-035E
	0.96	5.0	x			x								60-050E
	0.95	0.4		x	x		x				x	x	x	50-004C
	0.95	2.0	x											50-020C
	0.95	5.0	x			x			x					50-050C
	0.95	9.0	x			x			x					50-090C
Hercules Powder Co.														Hi-Fax
	0.945	†		x				x						1800
	0.945	†		x			x				x			1700
	0.945	0.2	x	x	x		x					x	x	1600
	0.945	0.6	x	x	x									1400
	0.945	1.5	x											1300
	0.945	3.5	x	x		x								1200
	0.945	5.0	x	x		x			x					1100
Eastman Chemical Co.														Tenite
	0.918	0.3		x				x						810
	0.918	1.15		x		x		x			x			831
	0.918	1.7		x		x	x	x	x		x			800
	0.918	3.5	x	x	x	x			x					859
	0.917	7.0	x	x		x			x					808
	0.915	20.0	x						x					811
	0.914	30.0	x											884
	0.910	200								x				812
	0.923	0.3		x				x						863
	0.923	1.15		x	x	x		x			x			853
	0.923	1.7	x	x	x	x	x	x	x	x				860
	0.923	3.5	x	x		x			x					872
	0.923	7.0	x							x				846
	0.923	20.0	x											840
	0.928	2.25	x	x		x								874
	0.928	14.5	x											870
	0.928	29.5	x											873
	0.933	0.7		x		x								1000
	0.934	1.7	x	x		x	x		x		x			1001
	0.935	7.0	x			x								1002
Koppers Co., Inc., Plastics Div.														Dylan
	0.917	1.5	x								x			1010
	0.917	2.1	x	x	x	x								1020
	0.916	10.0	x											1100
	0.915	21.0	x											1200
	0.921	7.0	x											2072
	0.921	20.0	x											2201
	0.922	35.0	x											2350
	0.926	1.2	x	x		x					x			3014
	0.928	7.0	x											3072
	0.930	10.0	x											3102
	0.930	20.0	x											3202
	0.935	1.2	x	x							x	x		4014
														Super Dylan
	0.953	0.2		x	x		x	x			x	x	x	6002
	0.953	0.4		x	x						x	x		6004
	0.953	0.8	x	x	x									6008
	0.953	1.5	x											6015
	0.953	3.0	x											6030
	0.953	6.0	x	x		x			x					6060
	0.953	9.0	x	x		x			x					6090

† Melt index not measurable by standard method. Reduced Specific Viscosity ratings: Series 1800, 4.5 to 6.5: Series 1700.3.5 to 4.5

*Based on data supplied by the resin manufacturers listed. For other sources of polyethylene resins and molding compounds, see Advertisers' Index, p. 28, and Directory Index, p. 1078. Where density is reported as "low," "medium," or "high," basis is: low = to 0.925; medium = 0.925 to 0.940; high = 0.940 and over.

Polyethylene resins and their uses* *(Con't)*

Manufacturers	Density	Melt index — average	Injection molding	Extrusion	Blow molding	Film	Wire coating	Cable jacketing	Coating	Hot melt	Pipe extrusion	Thermoforming sheet	Monofilaments	Trade Designations
E. I. du Pont de Nemours & Co.														Alathon
	Low	2.1	x		x	x								10
	Low	1.8	x			x								14
	Low	4.0				x			x					15, 16
	Med.	23.0	x											17
	Low	25.0	x											18
	Low	2.1	x		x									20
	Low	3.0	x		x									22
	Low	3.4				x								23A
	Med.	3.0	x		x	x			x					34
	Med.	0.6										x		31
	Low	1.7					x							5, 5B
	Low	0.3					x							3C, 4
	Low	2.0				x								5F
	Med.	2.0									x			25
Monsanto Chemical Co.														Monsanto
	0.917	1.9		x		x								706
	0.917	3.1		x		x								13406
	0.921	3.1		x		x								214061
	0.917	3.1		x		x								10406
	0.919	0.3		x				x						14202
	0.917	1.3		x				x						12253
	0.917	1.7		x			x							11302
	0.920	1.3		x			x							MPE-10
	0.917	3.0	x											805
	0.917	7.5	x											935
	0.917	23.0	x											975
	0.926	9.0	x											9352
	0.926	23.0	x											9752
	0.917	3.1		x					x					406
	0.926	7.0		x					x					5362
	0.920	1.2			x									2541
Phillips Chemical Co.														Marlex
	0.95	0.15 to 8			x	x							x	5000
	0.96	0.2		x		x							x	6000-2
	0.96	0.9	x											6000-9
	0.96	1.5	x											6000-15
	0.96	3.5	x											6000-35
	0.96	5.0	x			x								6000-50
Spencer Chemical Co.														Poly-Eth
	Low	2.0	x	x										1005
	Low	8.0	x	x										1007
	Low	22.0	x	x										1008.5
	Low	50.0	x	x										1009
	Low	35.0	x	x										1709
	Med.	1.0	x	x										Hi. D 1504
	Low	8.0		x								x		2007
	Low	2.0		x		x								2205
	Low	4.0		x		x			x					2206
	Low	8.0		x		x								2477
	Med.	1.0		x		x			x					Hi. D 2504
	Low	2.0		x							x			3215
	Med.	1.0				x					x			Hi. D 3504

Manufacturers	Density	Melt index — average	Injection molding	Extrusion	Blow molding	Film	Wire coating	Cable jacketing	Coating	Hot melt	Pipe extrusion	Thermoforming sheet	Monofilaments	Trade Designations
U. S. Industrial Chemical Co.														Petrothene
	0.916	0.3		x			x	x						300
	0.916	1.0		x	x	x	x					x		301
	0.916	1.5		x			x							302
	0.916	2.0		x					x					100
	0.916	3.0	x	x		x			x					200
	0.916	3.0	x	x		x								204
	0.916	5.0	x	x	x	x								201
	0.916	8.0	x	x					x					203
	0.916	22.0	x											202
	0.920	5.0		x		x			x					210
	0.924	1.0		x		x								307
	0.924	2.0		x	x						x			102
	0.924	3.0	x	x		x			x			x		205
	0.924	5.0	x	x	x	x								206
	0.924	8.0	x	x		x			x					207
	0.924	22.0	x											208
	0.929	5.0	x	x		x			x			x	x	239
	0.929	22.0	x											241
Union Carbide Plastics Co., Division of Union Carbide Corp.														Bakelite
	0.92	2.0	x											DYNH-1
	0.935	6.0	x											DPD-7365
	0.95	2.0	x											DMDA-6001
	0.96	3.0	x											DMDA-7004
	0.92	1.3		x			x							DFD-2005
	0.93	0.3		x			x							DFD-6505
	0.95	0.3		x			x					x	x	DGD-4100
	0.93	0.3						x						DFD-6015
	0.95	0.4			x									DMDA-4901
	0.96	1.0			x									DMDA-5700
	0.92	0.7			x									DYNJ-1
	0.917	2.0		x		x								DYNH-3
	0.95	2.5		x		x								DGDB 4002
	0.95	6.5		x		x								DGDA 4552
	0.923	2.0		x		x								DFD-0111
	0.92	4.0							x					DFD-3200
	0.95	6.5							x					DGDA-7401
	0.96	6.5							x					DGDA-3401
	0.943	0.3		x							x			DHD-4022
	0.96	0.2		x								x	x	DGDA-5211

Manufacturers	Density	Melt Index	Major Uses	Trade Designation
Semet-Solvay Petrochemical Div., Allied Chemical	Low	180 cps$^+$	Paper coatings, pastes, polishes, ink, rubber & plastics, processing aid	A-C 6 A-C 6A
	Low	100 cps$^+$	Processing aid for rubber, paper coating	A-C 617-617A
	Low	4000 cps$^+$	Paper coating	A-C 615
	Low	220 cps$^+$	Paste polish, paper coating	A-C 7
	Low	230 cps$^+$	Blending with waxes & oils	G-201
	Low	160 cps$^+$	Emulsion polishes, textile finishes	A-C 629
	High	15	Injection molding	A-C 150
	High	0.01	Under development	AC-X
	High	<0.20*	Pipe	A-C Pipe Compound

$^+$Viscosity is too low to use melt index. Values given in cps. at 140°C.

*D1238-52T with 27. 5 lb. wt. at 310° C.

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*Based on data supplied by the resin manufacturers listed. For other sources of polyethylene resins and molding compounds, see Advertisers' Index, p. 28, and Directory Index, p. 1078. Where density is reported as "low," "medium," or "high," basis is: low = to 0.925; medium = 0.925 to 0 940; high = 0.940 and over.

freezing takes place. In the crystal, the spatial arrangement of the molecules is in a definite geometric configuration.

MEDIUM-DENSITY POLYETHYLENE

Commercial quantities of a new type of medium-density polyethylene have recently become available. These medium-density resins have properties that fall between those of high-density and low-density types, although they are made by a modification of the high-pressure process.

The high-density polyethylene manufacturers are not overlooking the importance of the medium-density polyethylene field. Low-pressure processes can cover the entire range of densities from 0.92 to 0.96 by slight modifications, and commercial polyethylenes covering a range of intermediate densities are on the market.

Since density is so closely related to the physical properties of polyethylene, desired end-use properties can be obtained by an increase in density. The relationship between many of the properties and density is not always a straight-line relationship, so that a moderate increase in density may result in a significant improvement in some properties.

One of the limitations to the use of the low-density polyethylene, for example, is its permeability to many liquids and gases. This permeability is greatly decreased by an increase of density, and a good deal of the improvement possible[2] is obtained in the intermediate range. Heat resistance is in the same category.

The improved heat resistance of medium-density polyethylene over the low-density types permits the fabrication of boilable products—food packages, housewares, children's toys, etc.—but does not permit steam sterilization at 250° F. In addition, some of the properties which are sacrificed because of higher density—impact strength, fold endurance, etc.—reportedly will show less of a loss in the medium-density range.

The range on the melt index scale where the transition between waxy and plastic polyethylene appears is also influenced by density. In the medium-density range, the edge of transition to the waxy state is in the vicinity of melt index 8 or 10, so that materials with plastic properties can be made up to a melt index of 2 or 3. This will generally permit normal processing. In low-density polyethylene, some manufacturers claim a melt index of 50 is still safely on the plastic side, yet in high-density polyethylene, one manufacturer claims that a melt index of 8 to 10 is already near the transition stage to wax. However, it should be noted that many other factors affect this transition. By altering molecular weight distribution, for example, this transition state can be raised or lowered. Hence it is possible to produce a high-density polyethylene with a melt index of 8 to 10 and still remain below the transition range. One manufacturer claims its linear polyethylene does not approach the wax stage at a melt index as high as 8. Differentiation should also be made between the type of waxes obtained by increasing the melt index in low- and high-density polyethylenes. They are as different as the plastics themselves.

HIGH-DENSITY POLYETHYLENE

In the production of high-density polyethylene, ethylene is dissolved in a solvent at moderate pressures, usually 500 to 1000 p.s.i., and the solution is placed in contact with one of a number of widely differing catalysts which are insoluble in the solvent. Active centers on the surface of the catalyst polymerize the ethylene by means of a co-ordinating or directing mechanism which, in most cases, results in a "straight chain," or substantially unbranched polyethylene molecule.

The absence of branches permits the molecules to pack together more closely and results in a denser material.

One theory proposes that in all polyethylenes there is some tendency for the molecules to conform to each other to form crystallites. The unbranched material is able to do this more completely. The term "straight chain" is often misleading since the configuration of the molecule is actually coiled. When these coils crystallize they form an interlocked spiral crystallite. A number of these crystallites grow out from a center into a structure called a spherulite. The general picture is not unlike a mass of well-entangled fine springs.

In low-density polyethylene, crystallites and spherulites are embedded in a considerable amount of amorphous material which is responsible for the flexibility, and also for the permeability. This amorphous material also adds to shock resistance by distributing stresses. In the high-density material, little of such yielding material remains, and the size of the spherulites becomes extremely critical.

Spherulite size may be controlled by the cooling rate of the melt, slow cooling resulting in growth of the spherulites to a large size, and fast cooling to a much smaller size. The change in size of these spherulites in a molded item, due to annealing, may cause stresses which result in embrittlement of the part. Parts of uniform density, obtained by proper molding conditions, will not exhibit this phenomenon even after use at elevated temperatures. Excessively high mold temperatures combined with extreme mold packing will result in comparatively low impact strength in the gate area of the molded item, especially in thin sections.

Thermal cracking may also occur when linear polyethylene is excessively stressed and exposed at elevated temperatures. A decrease in density, increase in molecular weight, and narrowing the molecular weight distribution, or a change of only one parameter while holding the others constant, will improve the resistance to this type of thermal failure.

All of the commercially available polyethylenes may be effectively stabilized from thermal embrittlement caused by oxidative degradation.

Since the high-density polymers are still simply polyethylenes, they require the usual protection from

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[2] One manufacturer claims that 80% of the improvement possible has already been obtained in the intermediate range. Another holds that physical properties are a function of density in the range of 0.91 to 0.96 and that only 25% of the possible improvement is obtained.

TABLE I: Comparison of properties of polyethylene in the three density classes

Property	*Low-density*	*Medium-density*	*High-density*
Density	0.910-0.925	0.926-0.940	0.941-0.965
Hardness (Shore D)	40-50	50-63	63-70
Stiffness modulus, p.s.i.	10,000-25,000	25,000-50,000	50,000-140,000
Tensile strength	1500-2000	2000-2800	2800-6400
Heat resistance, °F.	212	240	250

the degrading effects of oxidation and sunlight. Commercial antioxidants have proved effective. Carbon black is still the best light absorber for wire, pipe, and other items that will be subjected for any length of time to outdoor exposure.

APPLICATIONS

All the polyethylenes—low-density, medium-density, and high-density—can be molded or extruded into a wide variety of useful products. Some of the more outstanding market areas for the various polyethylenes are discussed below.

Injection molding

Use of polyethylene has grown rapidly in the molding field because of its "nonbreakability," flexibility, ease of processing and coloring, chemical resistance, and low cost. Molding today accounts for about 16% of the polyethylene produced.

For injection molding, polyethylene in pellet form is available with melt indices ranging from 0.50 to 50. Molders may choose a type that best suits their requirements for molding performance and physical properties. The high melt index types permit molding of large objects such as wastebaskets and garbage cans, and also offer the additional advantages of superior gloss. Lower melt index types find use in applications requiring greater strength and resistance to environmental cracking. Improved rigidity and better gloss can be obtained with an increase in density.

Over half of the low-density material used for molding goes into such housewares as bowls, buckets, wastebaskets, garbage cans, containers, etc. Other large outlets for molded low-density polyethylene are closures for squeeze tubes; spouts for detergent cans; industrial parts, drums, and carboys; and shoe parts. Toys alone consume 15% of all polyethylene sold for molding applications.

Medium-density type materials have found many new uses. They have improved stiffness and gloss, without much sacrifice of flow properties, coupled with improved heat resistance. They are already being used extensively in housewares.

The inherent hardness of the high-density polyethylenes imparts a surface gloss to molded items. This attractive gloss is easily obtained even with a relatively low melt index.

A large percentage of the high-density material is currently being injection molded into a wide variety of consumer products. The most significant volume of injection molded items is housewares and industrial parts. Molding cycles can be reduced by using the higher flow types (2.0 to 5.0 melt index).

Industrial applications for high-density polyethylene are expanding rapidly. Large carrying cases (tote boxes), housings, closures, appliance parts, etc., are a few of the most promising applications. Large parts will, for the most part, utilize the higher flow types while such items as silverware baskets, furniture parts, etc., will take advantage of the increased toughness and stress cracking resistance of the lower melt index materials.

Film and sheeting

To date, more polyethylene has gone into film than into any other form. Since 1953, more than a third of all polyethylene used in the U. S. has been converted to film. Over 75% of the film produced now goes into the packaging of foods, textiles, soft goods, toys, hardware, machinery, and chemicals. Industrial packaging, e.g., drum and carton liners, and polyethylene shipping bags for chemicals, foodstuffs, etc., offer tremendous markets for polyethylene film, as do also bread wraps and garment bags for dry cleaning establishments. Although the importance of polyethylene film in the packaging industry will undoubtedly continue to increase to make it one of the largest markets for the material, some nonpackaging applications are expected also to grow rapidly in the future. Agricultural and construction uses, in particular, are gaining momentum.

Polyethylene film is produced mainly by extrusion, either from a flat die with water or chill-roll quenching or by the blown tubing method. Some film is produced by calendering but the difficulties of this process have greatly limited its commercial development. Some of the new films provide exceptional clarity combined with improved slip and blocking characteristics. To obtain improved stress crack resistance the user may select one of the blends of polyethylene with rubber or other materials. Film made from high-density polyethylene displays excellent slip properties, and is completely non-blocking. The flat die-water tank and flat die-casting roll techniques produce high-density film having excellent transparency and surface gloss and represent a real challenge to cellophane markets. The higher melt index types are preferred since clarity is improved over the lower melt index resins.

"Blown" high-density film is noticeably less transparent than low-density film. In both cases, the higher stiffness modulus is quite apparent. This is desirable for pushing film through automatic packaging machinery.

Using the blown tubing method, heavy gage high-density tubing is being produced. This heavy tubing (up to 20 mils) offers an economical source of sheeting for vacuum forming.

The clarity of flat die film made

from high-density polyethylenes offers distinct attractions to the overwrap packaging field in general.

The technique for sheet extrusion is almost identical to that used for impact-type styrene sheet. Outstanding surface quality can be achieved with a flat die and a three-high roll stack takeoff. For example, a combination of 390° F. stock and 220° F. roll temperatures produces a high-gloss surface which is not lost during subsequent forming operations.

The large-scale use of heavy sheeting, however, has been retarded by the lack of well-developed fabrication techniques. As the necessary techniques are worked out, and sheeting with the required properties becomes available, a great increase in the production of polyethylene objects by the thermoforming of heavy sheet will occur.

High-density polyethylene sheet may be successfully thermoformed on existing equipment; however, due to the low thermal conductivity of polyethylene and high softening point, cycle times are longer than those used for impact-type polystyrenes. Therefore, to decrease this cycle and improve the economics of this process, higher heater watt densities are required. Special heating techniques, such as sandwich heating, are also very valuable for fast heating of thick sheets.

The use of ultra-violet inhibitors increases substantially the expected outdoor life of unpigmented polyethylene film and molded articles.

Electrical insulation

High electrical resistivity and good dielectric characteristics, particularly at high frequencies, have made polyethylene an important material in electrical insulation. About 9% of the polyethylene now produced is used for electrical insulation or jacketing. During World War II, nearly all the available polyethylene was used for insulation in communication service, particularly high-frequency applications. Polyethylene is used as an outer jacket on power cables, telephone lines, television lead-in wire, and appliance wire where it serves as both insulation and as a protective barrier against moisture, weathering, and abrasion. Some of the higher melt index types are also used, usually compounded with polyisobutylene or synthetic rubber to improve their environmental crack resistance. Improved crack resistance can also be obtained by the use of low melt index grades of resin. When melt index gets extremely low, however, there is an extrusion problem.

Severe difficulties initially encountered with the thermal stress rupture failure of the early high-density polyethylenes retarded its acceptance for electrical applications on any large scale. However, considerable progress has been made in overcoming these technical difficulties and full acceptance is anticipated.

Mention should also be made of the use of foamed polyethylene in the electrical field. Though its volume of use today is small, the potential for this material is very large, if certain technical and production problems can be overcome.

Pipe

Polyethylene pipe is finding steadily increasing acceptance for farm, mine, and home uses, primarily in the transportation of cold water. It is available in sizes ranging from ½ to 6 in. in diameter. Its principal advantage over other plastics and metal pipes is its flexibility, which allows lengths up to 1500 ft. to be coiled for shipment. This results in great ease of installation. Other advantages are its immunity to rupture through freezing, and complete resistance to corrosion. Polyethylene pipe is colored black (with 2 to 3% of finely divided carbon black) for protection against ultra-violet light. At present, pipe accounts for about 13% of the polyethylene produced in the U. S., and this proportion will probably not change greatly in the next few years.

The position of high-density polyethylene in the pipe field has not yet been fully established, but it is not expected to compete seriously with the more flexible materials in their present uses.

One of the desirable features of low-density polyethylene pipe is its flexibility, which permits marketing in easily-handled coils, whereas the higher stiffness modulus of the high-density type will necessitate shipment of larger sizes in straight lengths, with the accompanying need for joints. In many installations, however, the increased heat resistance and the possibility of use of high-density pipe in portable water systems will be of greater importance than the reduced flexibility. Long-time burst strength of high-density pipe has been improved.

Butt welding has been shown to be an excellent method for joining the semirigid, high-density pipe. Standard threaded fittings may also be used in certain applications where very low pressures are involved, but in general this method is not recommended, since it increases danger of cracking. High-density polyethylene pipe will find use in many low-pressure applications in chemical processes, food processing plants, electrical conduit systems in corrosive areas, etc.

Coatings

Of the various methods of coating other materials with polyethylene, only extrusion-coating is of commercial importance at present. In this process, a very thin film of polyethylene is extruded directly onto a moving web of paper, aluminum foil, or other sheet material. About 4% of the polyethylene consumed in the U. S. goes into extrusion-coating applications. The great bulk of this is extruded onto paper for multiwall bags, wrapping and lining papers, and pouch bags. Coated aluminum foil is heat-sealable, and provides a package which is absolutely waterproof. Cellophane and polyester film coated with polyethylene are finding increasing acceptance for packaging applications requiring greater strength, impermeability, or heat resistance than would be provided by polyethylene alone. Fabrics are extrusion-coated with polyethylene to render them waterproof, or better able to retain finely powdered materials. Non-woven mats of cellulose fibers are coated to produce disposable baby diapers and hospital sheets. A probable large future application is the coating of board stock for milk cartons and other liquid containers.

To all these combinations, low-density polyethylene contributes wear resistance, heat-sealability, form retention, and moisture resistance. The lower permeability of high-density polyethylene may lead to its use in extrusion-coating. Slight modifications in coating techniques are employed with high-density polyethylene, but the greatest improvements can be made by modifying the resin itself in order to be able to use it on existing coating equipment. Experimental polymers under development show much promise in this respect. High-density polyethylene may be coated on existing equipment today, but in thicknesses which make it economically impossible to compete with low-density polyethylene.

Medium-density polyethylene resins are finding large-scale usage in the extrusion-coating of paper and films. The improved permeability resistance of a medium-density resin makes it a natural for this type of application.

Metal surfaces can be coated with a heavy layer of polyethylene by flame spraying. A fluidized-bed technique is used to coat small, irregularly-shaped metal objects.

The coating of heated metal surfaces with air-suspended powdered polyethylene by a sintering process has also increased in popularity.

Filaments, bottles, and tubes

This market is relatively small for low-density polyethylene, and complete displacement by higher density materials can be expected, together with rapid growth in total input. Filaments produced from high-density polymers can be oriented by stretching 800 to 1000% and have shown tensile strengths comparable to the best synthetic fibers, with excellent abrasion resistance. The combination of low cost, high-tensile, good chemical inertness, and good heat resistance should be of real value in cordage, fish nets, filter cloths, upholstery, and the like.

Polyethylene can be blow molded into bottles for cosmetics, drugs, foodstuffs, and chemicals, and has had particular success in baby bottles. In this field, polyethylene has gained great popularity because of low cost, resistance to breakage and corrosion, "squeeze" flexibility, and sales appeal. In the blow molding process, an extruded tube is formed to shape in a mold by air pressure. Large carboys and drums can be made by welding or blow molding.

Special polyethylenes have been developed to meet the particular flow requirements of various custom processes. In some packaging applications, the use of polyethylene alone has been restricted by the diffusion of essential oils and other volatile substances through the wall of the container. However, this limitation has been reduced by the use of coatings. Coated polyethylene packages offer perhaps the most promising growth prospects for the area of polyethylene bottles, tubes, and cans.

High-density polyethylene can be processed in conventional equipment in accordance with the usual procedures for making bottles of low-density polyethylene. For many applications, the increased rigidity and heat resistance will outweigh the reduced flexibility. "Squeeze bottles" can be made by designing plane or slightly curved faces which will display a diaphragm or "oil-can" action. Extruded polyethylene tubing fitted with two metal ends also shows possibilities. The lower permeability of the high-density bottles should permit a greatly broadened use of plastic bottles and containers in the packaging of cosmetics, pharmaceuticals, and miscellaneous chemicals.

Miscellaneous uses

There are a number of minor applications for polyethylene which, in total, account for an impressive quantity of material. Thick compression molded slabs are used in the shielding of nuclear reactors. Thinner sheets are used in the construction of tanks, tank linings, and many types of chemical process equipment. Small-diameter tubing is used in aerosol dispenser cans, automobile battery separators, etc.

Other uses for polyethylene are potting delicate electrical mechanisms by injection molding and centrifugal casting of large tubes or pipe. Low-molecular-weight polyethylenes are used in emulsions, wax blends, and in rubber processing.

References

Consult the Subject Index for additional information concerning polyethylene. For information on injection molding, see p. 594; on compression molding, see p. 631; extrusion, see p. 695. See also the Adhesives, Coatings, Films, Laminates, and Plastics Properties Charts for information on properties and trade designations. For sources of polyethylene resins and molding compounds, see Directory Index, p. 1078.

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Fluorocarbons

TFE-Fluorocarbon Resin

BY R. B. FEHR*

The high polymer of tetrafluoroethylene created by polymerization under carefully controlled conditions, polytetrafluoroethylene (TFE-fluorocarbon resin) has a molecular structure consisting of carbon and fluorine atoms only. As a consequence, it has a combination of chemical and physical properties unsurpassed by any other single material of construction. Articles fabricated of TFE-fluorocarbon resin exhibit extreme inertness to chemical attack, very high thermal stability, low dielectric loss and high dielectric strength, nonadhesion and low frictional properties, and outstanding retention of properties over a wide temperature range. All of this is a result of the pure fluorocarbon system where the primary bonds in the polymer chain are very strong, the secondary valence forces between adjacent chains are weak, and the symmetrical arrangement of fluorine atoms forms a sheath protecting the carbon chain.

TFE-fluorocarbon resins (Teflon[1]) are available in the forms listed in Table I, right.

Properties

Because of their low dissipation factor and low dielectric constant, TFE-fluorocarbon resins are widely used in the electronic industry. The dissipation factor and dielectric constant are unchanged from frequencies of 60 cycles to 10,000 megacycles. In addition, these properties are only slightly altered at elevated temperatures. For example, over a frequency range of 10^2 to 10^4 cycles, the dissipation factor does not change within the limits of measurement to temperatures as high as 597° F.

Another unusual property of TFE-fluorocarbon resins is their exceedingly low coefficient of friction—lower than that for any other solid. The static coefficient is lower than the dynamic value and thus TFE-fluorocarbon resins do not exhibit a slip-stick type of motion, and bearings and piston rings of TFE resins are gaining wide acceptance in nonlubricated service.

While many of the mechanical strength properties are adequate for many uses but not exceptional, the impact strength is extremely high. Even though many plastics exhibit better properties at room temperature, there are no plastics that retain useful mechanical properties over as wide a temperature range. For example, after one month at 480° F., molded bars showed only a 1% loss in tensile strength. An extreme example of its utility at high temperature is as a totally confined gasket at a temperature of 930° F. under a pressure of 15,000 p.s.i. This is possible since the melting point of TFE-fluorocarbon resins is raised with increasing pressure.

The value of TFE-fluorocarbon resins for certain applications can be considerably enhanced by the use of reinforcing agents. Such modification improves certain mechanical properties and permits compositions based on TFE-fluorocarbon resins to be tailored to a wide variety of chemical, mechanical, and electrical applications. As an example, resistance to wear by rotating shafts can be increased as much as 500 times through the use of additives. Furthermore, the modified compositions retain most of the outstanding properties of uncompounded TFE-fluorocarbon resins. Elongation and impact strength are lowered, but in most instances these changes do not impair the usefulness of the article.

Processing methods

Some of the properties of TFE resins are relatively insensitive to fabrication techniques, while others are, to a large extent, under the control of the fabricator. Good thermal and chemical resistance, nonadhesiveness, low dissipation factor, and low dielectric constant are inherent in the chemical structure of the tetrafluoroethylene molecule and are relatively independent of the fabrication method. On the other hand, properties such as stiffness, flex life, permeability, and tensile properties are influenced by fabrication. For this reason, it is recommended that anyone contemplating new designs incorporating TFE-fluorocarbon resins work closely with an experienced fabricator whenever possible.

TFE resins are fabricated by a number of techniques including screw extrusion, ram extrusion, preforming followed by pressure or

TABLE I: Grades of TFE-fluorocarbon resins

Teflon grade	*Description*	*Use*
1	General purpose molding powder.	Gaskets, packing, seals, rings, electronic components, sheets, rods, heavy wall tubing and bearings
5	Special purpose powder for molding cylindrical shapes for the production of skived tape	Tape and molded shapes for chemical, electrical, mechanical and nonadhesive applications
7	Special purpose ultra-fine molding powder for use where highest quality void-free moldings are required	Tape and molded shapes for chemical, electrical, mechanical and nonadhesive applications
6	Special purpose powder usually compounded with naphtha to aid in extrusion	Thin wall tubing, wire insulation and electrical tape
30	Aqueous dispersion	Coating of fabrics and metals

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* Polychemicals Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

[1] Trademark of Du Pont.

References and Recent Developments were prepared by the editors.

free sintering, extrusion with an extrusion aid (naphtha), coating, and dip coating and impregnation. These techniques, while different, have three basic steps in common: 1) cold forming; 2) sintering; and 3) cooling. The different methods are applicable to the various forms in which the resin is available.

Sheeting of TFE-fluorocarbon resins can be fabricated or treated to make it cementable to various substrates with a variety of conventional adhesives. The treatment may be applied to any desired area so as to preserve the low frictional antistick properties on untreated surfaces.

For applications where continuous TFE-fluorocarbon resin joints are required, as in tank linings for chemical process equipment, sheet stock may be heat bonded. This technique employs a simple contact heater at a temperature of about 710° F. with the aid of flux and contact pressure of about 35 p.s.i.

TFE-fluorocarbon resins are extremely stable at high temperatures. They can be used continuously up to 500° F. and, in special applications, even higher. However, at one stage in its processing, the resin is heated to temperatures above 650° F. These temperatures exceed the point where small quantities of gaseous decomposition products are evolved, some of which may cause extreme discomfort if inhaled. Thus a necessary safety precaution is adequate ventilation.

TABLE II: Properties of molded TFE-fluorocarbon resins

Property	*Units*	*A.S.T.M. Method*	
Tensile strength, 73° F.	lb./sq.in.	D638-52T	2500-3500
Elongation, 73° F.	%	D638-52T	200-300
Flexural strength, 73° F.	lb./sq.in.	D790-49T	did not break
Stiffness, 73° F.	lb./sq.in.	D747-50	50,000-90,000
Impact strength, Izod, —70° F.	ft.lb./in.	D256-47T	2.0
73° F.	ft.lb./in.	D256-47T	3.0
170° F.	ft.lb./in.	D256-47T	6.0
Hardness, Durometer		D676-49T	D50-D65
Compressive stress at 1% deformation, 73° F.	lb./sq.in.	D695-52T	600
at 1% offset, 73° F.	lb./sq.in.	D695-52T	1,000
Coefficient of linear thermal expansion per °F., 73-140° F.		D696-44	5.5 × 10^5
Thermal conductivity, 0.18 in.	B.t.u./hr./sq.ft./°F./in.	See footnote 1	1.7
Specific heat	B.t.u./lb./°F.		0.25
Deformation under load, 122° F., 1200 lb./sq.in., 24 hr.	%	D621-51	4-8
Heat-distortion temperature, 66 lb./sq.in.	°F.	D648B-45T	250
Dielectric strength, short-time, 0.080 in.	v./mil	D149-44	400-500 See footnote 2
Surface arc-resistance	sec.	D495-48T	See footnote 3
Volume resistivity	ohm-cm.	D257-52T	$>10^{18}$
Surface resistivity, 100% R.H.	megohms	D257-52T	$>10^{11}$
Dielectric constant, 60 cycles		D150-54T	2.1
10^3 cycles		D150-54T	2.1
10^6 cycles		D150-54T	2.1
10^8 cycles		D150-54T	2.1
Power factors, 60 cycles		D150-54T	<0.0003
10^3 cycles		D150-54T	<0.0003
10^6 cycles		D150-54T	<0.0003
10^8 cycles		D150-54T	<0.0003
Water absorption	%	D570-42	<0.01
Flammability	in./min.	D635-44	nonflammable
Specific gravity		D792-50	2.1-2.2
Resistance to weathering			excellent
Static or kinetic coefficient of friction against polished steel		See footnote 4	0.04

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* Data shown are average values and should not be used for specifications.

[1] Measured by Cenco-Fitch apparatus.

[2] Value is 1000-2000 v./mil in thicknesses of 5 to 12 mils.

[3] Does not track.

[4] Various methods used.

TFCE-Fluorocarbon Resin

BY J. A. JUPA*

The polymer molecule of trifluorochloroethylene consists of a carbon skeleton and two halogens —fluorine and chlorine—present in a mol ratio of 3:1. The chlorine atom contributes to the transparency, moldability, and rigidity characteristics of the plastic, while the fluorine atoms are responsible for its chemical inertness, thermal stability, and zero moisture absorption.

The resulting Kel-F[1] brand thermoplastic materials have a wide range of molecular weights: high-molecular-weight resins, used for molding and dispersions, are in the range of 300,000 to 400,000. Kel-F 270 and 300 are representative of the foregoing materials. More recently, a modified form of polytrifluorochloroethylene (Kel-F 500) has been introduced. Supplied in the same high-molecular-weight category, this resin offers improved flow with greater resistance to crystallinity, particularly upon heat aging. However, lower-molecular-weight materials, existing as oils, greases, and waxes, have boiling points from —110° C. to about 230 C. at 1 mm. Hg. The lower-molecular-weight oils and greases are useful as plasticizers, stopcock greases, damping fluids, etc.

Molding and extrusion materials: These are hard, dense thermoplastic resins with extreme chemical inertness, thermal stability, and high impact, tensile, and compressive strengths. The materials are supplied as high- or low-density molding powders.

The high-density molding powders are essentially ⅛-in. cylindrical pellets which have a compression ratio of 2:1. The low-density molding powders have a compression ratio of roughly 6:1 and are white, free-flowing powders.

Although there is a plasticizer

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* Industrial Plastics and Equipment Co., Elizabeth, N. J.

[1] Trademark of Minnesota Mining & Mfg. Co.

grade and a flexible type for wire coating and thin-wall tubing, the molding and extrusion materials may be classed generally as rigid rather than elastomeric (Rockwell hardness R111 to 115).

Plasticized materials are also available. The plasticizer has the same chemical and electrical properties as the high polymer.

The electrical characteristics of these molding and extrusion materials are also outstanding. The polymer does not carbonize when subjected to electrical arcing and withstands greater than 360 sec. when tested according to A.S.T.M. D495-42. Volume resistivity is outstanding over a wide temperature range. Its dielectric strength is 520 v./mil.

Dispersions: Dispersions were developed from polytrifluorochloroethylene polymers to extend the protection of this material to surfaces that do not lend themselves to the use of molded plastic because of size, design, or construction.

These dispersions consist of finely divided particles of the high-molecular-weight plastic suspended in a volatile organic liquid. Upon heat fusion, the dispersions form a tough, permanent protective coating with all the properties of the original plastic. Dispersions can be applied to many metallic, and certain nonmetallic surfaces by spray, spread, or dip-coating. Primers are available to increase adhesion.

Antistick characteristics are an important advantage of fluorocarbon dispersion coatings. Glues, inks, paints, greases, meats, waxes, candies, rubber, or casting resins will not readily adhere. When used to coat surfaces of processing equipment, clean-out and shut-down times are reduced and schedules speeded up.

FEP-Fluorocarbon Resin

BY R. L. RINDERMAN*

Many new design possibilities and processing economies will be feasible with a recent addition to the fluorocarbon family of polymers —Teflon[1] FEP-fluorocarbon resin, a copolymer of tetrafluoroethylene

Unsaturated perfluoro compound (*Perfluorobutene-2,* Halocarbon Products Corp.) copolymerizes readily with other monomers . . . is being studied as a modifier in development of special polymers . . . it undergoes reactions common to fluoro olefins.

Polytetrafluoroethylene (Teflon) resin dispersions (*Emralon,* Acheson Colloids Co., Div. of Acheson Industries, Inc.) are available in selection of binders for application of PTFE to heat-sensitive surfaces . . . the dispersions can be cured at about 300° F. . . . are offered for industrial uses . . . coatings for molds, drums, extrusion dies, gaskets, conveyors, pumps, slides, engine parts—and for home applications . . . window casings, drawer guides, casters, door hinges.

Tapes (*Fluorolin,* Joclin Mfg. Co.) made of virgin polytetrafluoroethylene (Teflon) are coated with pressure-sensitive adhesive . . . include skived, extruded unsintered, extruded sintered, and cast film.

Massive molded polytetrafluoroethylene (Teflon) rods and tubes (*Chemplast,* Inc.) . . . produced by special techniques . . . reported free from cracks and fissures.

Industrial uses are foreseen for polytetrafluoroethylene (Teflon) tape (The United States Gasket Co., Plastics Div. of The Garlock Packing Co.), produced in widths to 24 in. and in thicknesses from 0.005 to 0.096 in. . . . currently finding application for ski liners on planes in frigid regions.

Dry bearings, with a surface of a mixture of tetrafluoroethylene (Teflon) and lead (*DU,* United States Gasket Co., Plastics Div. of The Garlock Packing Co.) has a steel backing on which is sintered a thin lining of spherical bronze . . . Teflon-lead mixture impregnates the bronze, leaves thin layer on the bearing surface. . . . Material has low friction with no slip-stick characteristics.

Two thermal-curing pressure-sensitive polytetrafluoroethylene (Teflon) tapes (*Temp-R-Tape C,* The Connecticut Hard Rubber Co., and *Permacel 422,* Permacel-LePage's Inc.) have silicone adhesives . . . both will withstand 500° F. operating temperatures . . . *Tempo-R-Tape* has 1½ mil backing; *Parmacel,* 2 mil . . . electrical uses are indicated . . . especially where high dielectric, extremely thin, easy-to-apply insulation is desirable.

Rods of polytetrafluoroethylene (Teflon) are available (*TSI,* Tri-Point Plastics, Inc.) in almost fifty diameters ranging from 0.125 to 1.25 inches . . . used in electronics and guided missiles.

Electrodeposition of polytetrafluoroethylene (Teflon) resin on metallic and nonmetallic parts and subsequent fusing (Redel, Inc.) produces corrosion-resistant coating . . . claims include improved adhesion, less porosity, and better thickness control than with conventional dispersion coating.

Cable covering of polytetrafluoroethylene (Teflon) for high-temperature electronic wiring (*Multi-Tet,* W. L. Gore & Associates) is ribbon with side-by-side conductors . . . insulation is free of pin-holes.

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*Polychemicals Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

[1] Trademark of DuPont.

and hexafluoropropylene. While exhibiting most of the excellent properties of the TFE-fluorocarbon resins, the FEP resin offers the processing advantages of true thermoplastics. The FEP resin is available in pellet form for easier processing by injection molding and conventional screw extrusion.

Properties

By virtue of a fully fluorinated structure, the FEP-fluorocarbon resin retains, to a large extent, the hitherto unique properties of the TFE resins. Some of the outstanding properties of the FEP resin are:

1) Exceptional heat resistance. Parts fabricated from the FEP resin are capable of continuous service at temperatures up to 400° F. and higher than 400° F. under certain conditions.

2) Excellent dielectric characteristics. Like the TFE resins, the dissipation factor and dielectric constant of the FEP resin remain constant over a wide range of temperatures and over the entire range of frequencies measured to date (60 cycles to 60 megacycles). Volume resistivity is greater than 2×10^{18} ohm-cm., even after prolonged water soaking. The FEP resin will melt when exposed to an arc, but does not carbon-track.

3) Chemical inertness. The FEP-fluorocarbon resin is resistant to all known chemicals and solvents other than alkali metals under certain conditions, fluorine at elevated temperatures, and certain complex halogenated compounds such as chlorine trifluoride.

4) Low permeability. Films of resin exhibit a low permeability comparable to the best fabricated films of neoprene and butyl rubber. This low permeability, combined with excellent chemical resistance and ease of fabrication, makes sheeting of the FEP resin an excellent material for lining equipment for severe corrosive service at temperatures up to 400° F.

5) Toughness and strength. Over a wide range of temperatures, from −450 to 440° F., molded parts retain their mechanical toughness and strength.

6) Excellent weatherability. FEP resin is virtually unaffected by weather. It has remained unchanged when subjected to ultraviolet light, ozone attack, and extreme heat and cold.

7) Exceptional nonadhesiveness and ice release. Tests indicate that the adhesion to ice and frost is lower than that of other presently available plastics.

8) Zero moisture absorption.

The primary difference between the TFE and FEP resins occurs at high temperatures. Whereas the TFE resins become a rubbery gel above 621° F., the FEP resin melts at about 550° F and can be processed at 600 to 750° F. by conventional extrusion and injection molding techniques.

Applications

The melt extrudability of FEP-fluorocarbon resin allows the economical fabrication of high temperature, chemically resistant wire jackets in long continuous lengths on a wide range of primary insulations. Primary insulation with FEP resin is possible over the whole range of common conductor materials, such as silver, aluminum, copper, tinned copper, nickel- and silver-plated copper. A wide range of wire and cable constructions can be coated, striped, stripped, colored, and printed economically and without difficulty.

Film, tubing, rod, and irregular shapes have been successfully extruded by thermoplastic techniques. These forms are suitable for use in capacitors, resistors, insulators, and many other components requiring outstanding electrical and thermal properties.

The applicability of FEP resin to injection molding techniques permits rapid and economical mass production with conventional equipment. Difficult-to-machine parts, e.g., complicated shapes or thin sections, can now be fabricated economically. The excellent dielectric properties of the FEP resin make it especially appropriate for molding electrical and electronic parts such as high frequency connectors, microwave components, and insulators. Its excellent chemical properties and heat resistance make it particularly suitable for use in highly corrosive conditions at elevated temperatures.

Fabrication by compression and transfer molding is also feasible. It is possible to encapsulate transformers, resistors, coils, etc. Hermetically sealed units are feasible using molding techniques.

By the application of heat and pressure, film or sheeting of the FEP-fluorocarbon resin can be post-formed or bonded to a variety of substrates. Satisfactory bonds to such substrates as metals, glass, and the TFE-fluorocarbon resins can be obtained. Applications of this processing technique include laminates, printed circuits, and protective and nonstick linings.

By the powder-sinter technique, coatings of FEP resin can be produced on complex shapes of metal and other materials for resistance to high temperatures and corrosive conditions. Applications of FEP as a coating include motor hardware, chemical pumps and valves, and military weapons.

References

Consult the Subject Index for additional information concerning fluoroethylene. For information on injection molding, see p. 594; on compression molding, see p. 631, on extrusion, see p. 656. See also the Adhesives, Coatings, Films, Laminates, and Plastics Properties Charts for information on properties and trade designations. For sources of fluoroethylene resins, see Directory Index, p. 1078.

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Furane resins

By John Delmonte*

In recent months, there has been renewed activity in the development of furane resins for industrial purposes. Much of this has involved the use of furfural resins as modifiers of epoxies for the preparation of stable, chemically resistant coatings, laminates, and castings with improved resistance to oxidizing acids. In this work, as in the other impregnation, adhesive, and coatings applications described below, the furane resins, dark in color when cured, are characterized by good chemical resistance and good penetration of porous surfaces.

Origins and uses

Furfuraldehyde, which stems from vegetable byproducts, can be converted to furfuryl alcohol and tetrahydro-furfuryl alcohol. Both of these constituents are used extensively by the plastics industry. Pure furane resins can be made from furfuryl alcohol; tetrahydrofurfuryl alcohol esters are used as plasticizers for vinyls; furfuryl alcohol combined with acid catalysts yields liquid polymers for impregnation; furfuryl alcohol combined with aldehydes and acid catalysts gives viscous liquids which are used in cements, sealing compounds, and coatings; a combination of furfuraldehyde and ketones is used for coatings and impregnants; and furfuryl alcohol plus dimethylol urea produces noncrazing wood adhesives.

Processing

Unlike some of the other thermosetting polymers, furane resins remain as liquids until cured. When ready for conversion to an infusible solid, they increase in viscosity to form an irreversible gel which is cured to a final solid. As would be expected, due to the condensation-polymerization reaction, furfuryl alcohol resins undergo a substantial amount of shrinkage during cure. This shrinkage may be compensated for by the addition of appropriate chemical-resistant fillers such as silica, carbon black, and asbestos.

Furane resin systems can be baked after application to improve their usefulness. Room-temperature curing resins—aided by acidic-type catalysts—are also available.

In general, strong acid catalysts are preferred. These include hydrochloric and sulfuric acid, though in practice phosphoric acid and toluene sulfonic acids are usually used. To fulfill some of the requirements for adhesive pastes for acidproof bricks, viscous resinous compounds are blended with fillers to which the acid or acid-forming compounds have previously been added.

Applications

Impregnation: Whether impregnating plaster of paris castings or sand-foundry patterns, the rapid and effective penetration of furane resins is noteworthy. They also assist in the manufacture of grinding wheels because of their effective wetting action. In the form of thin liquids of 100% solids content and under 50 centipoises in viscosity, they penetrate into the dry material and, after curing, convert the plaster or sand into a strong and heat-resistant material. Plaster molds and tools now being prepared in this manner are suitable for high-temperature laminating or casting.

Adhesives and coatings: In the field of adhesives and coatings, particularly for use in chemical plants, the inertness of cured furanes to most acids, alkalies, and organic solvents make them valuable in many assemblies. Completed structures, such as tanks, ducts, towers, scrubbers, etc., have been successfully produced using glass reinforced furane resins.

Adhesion of acid-catalyzed furanes to wood, asbestos-cement, Masonite, and ceramics is excellent, but they are not satisfactory for metals. For such work, high-temperature curing materials must be used to attain the desired adhesion. No catalysts are required, but temperatures in excess of 325° F. must be applied.

Furanes are used as protective coatings in aluminum and copper molds for casting vinyl plastisols; also for tops of tables in chemical and medical laboratories.

TABLE I: Physical properties of a typical furane-glass laminate[1]

Density, g./cc.	1.60
Flexural strength, 75° F., p.s.i.	29,000
Flexural strength, 150° F., p.s.i.	29,000
Modulus of elasticity, p.s.i.	1,900,000
Resin component alone	
Compressive strength, p.s.i.	18,000
Shore D, room temp.	89/87
Shore D, 200° F.	82
Shore D, 300° F.	80

[1] Based on Jet-Kote X-8 laminate (No. 1500 fibrous glass), Furane Plastics, Inc.

References

Consult Subject Index for additional information on furane resins. See also the Adhesives and Coatings Charts for information on properties and trade designations. For sources of furane resins, see Directory Index, p. 1078.

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*Gen. Mgr., Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39, Calif.
References were prepared by the editors.

Inorganic plastics

By J. H. DuBois*

One of the original inorganic plastics materials was glass-bonded mica, first produced in the United States in 1923. Glass-bonded mica is prepared by mixing freshly ground natural micas and a low-melting-point electrical grade of glass. This mixture of glass and ground mica then is preheated until the glass becomes soft. At this point it is pressed to the shape that is desired by either one of two processing methods—compression molding or injection molding.

For fabricating purposes, sheet and rod materials are formulated with a minimum amount of glass and a maximum amount of mica. A different combination is used to get a high-plasticity material for molded products. High dielectric constant materials may be achieved by the inclusion of titanium dioxide or other titanates.

Glass-bonded mica molded products may be used at temperatures up to 650° F.; the fabricating material may be used at temperatures up to 800° F.

TABLE I: Properties of ceramoplastics

Property	*Value* *Injection molded*[1]	 *Compression molded*[2]
Electrical		
Dissipation factor, 1 mc.	0.0015	0.0015
Dielectric-constant, 1 mc.	9.2	7.2
Temp. coefficient of dielectric constant, 1 mc. p.p.m./° F.	120	135
Loss factor, 1 mc.	0.014	0.011
Dielectric strength, v./mil	400	500
Volume resistivity, ohm-cm., at 20° C.	5×10^{16}	1×10^{17} at 25° C.
at 250° C.	5×10^{11}	4×10^{15} at 100° C.
at 500° C.	1×10^{6}	4×10^{6} at 500° C.
Arc resistance, sec. (A.S.T.M.)	250	300
Mechanical		
Specific gravity	3.8	3.0
Density, lb./cu. in.	0.136	0.11
Impact strength (Izod), ft.-lb./in. of notch	0.7	1.85
Water absorption, % in 24 hr.	Nil	Nil
Hardness, Rockwell M	115-125	110-120
Knoop	600	550
Flexural strength, p.s.i.	13,000	15,000
Modulus of elasticity, p.s.i.	7×10^{6}	11×10^{6}
Compressive strength, p.s.i.	25,000	35,000
Tensile strength, p.s.i.	6,000	6,000
Specific heat, cal./g./° C.	0.14	0.17
Mold shrinkage	Nil	Not applicable
Maximum operating temp., ° F., continuous	700	850
short time	950	
Thermal conductivity, B.t.u./sq. ft./hr. (°F./in.)	3.2	3.5
cal./sq. cm./sec./ (° C./cm.)	0.00134	0.00095
Thermal expansion, in./in./° C., at 20 to 300° C.	11.4×10^{-6}	11.2×10^{-6}

[1] Based on injection molded Supramica 555.
[2] Based on compression molded Supramica 500.

Other good properties are total arc resistance, radiation endurance, negligible moisture absorption, total dimensional stability, and freedom from distortion under age and thermal cycling. The thermal expansion coefficient matches closely the stainless steel insert materials.

In processing these materials, proper proportions of mica and glass are mixed intimately with about 10% of water. The mixture is preformed under pressure of 4000 p.s.i. and dried to remove excess water. Compression molding is accomplished by heating preforms until the glass becomes plastic and then hot-pressing at 500 to 700° F. at approximately 4000 p.s.i. Most sections require careful annealing after they are molded.

Injection molding of glass-bonded mica is done by first preheating the charge, which is then manually transferred to the injection cylinder and injected into a closed mold maintained at a temperature of approximately 700 to 900° F. and at pressures from 10,000 to 50,000 p.s.i.

The ceramoplastic materials (Supramica 500, Supramica 555, Supramica 560)[1] are relatively new products composed of Synthamica, a pure, fluor-phlogopite synthetic mica, bonded with inorganic materials which enable them to be used in the 500° C. range for missile and supersonic aircraft components applications. The ceramoplastic materials also exhibit the moldability, the inclusion of inserts, and the ability to mold intricate detail not found in the true ceramic materials. Table I, left, lists physical properties.

References

See the Plastics Properties Chart for information on properties and trade designations. For sources of inorganic plastics, see Directory Index, p. 1078.

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* Consultant, J. Harry DuBois Co., Box 178, Montclair, N. J.; formerly with Mycalex Corp. of America, 125 Clifton Blvd., Clifton, N. J.

This article refers to glass-bonded mica and the ceramoplastics.

References were prepared by the editors.

[1] Trademarks of Mycalex Corp. of America.

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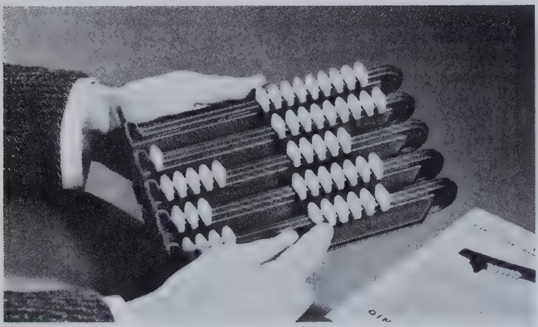
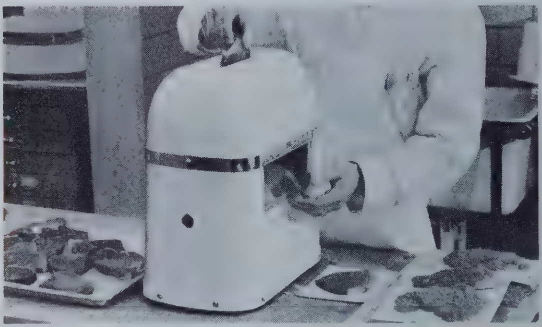
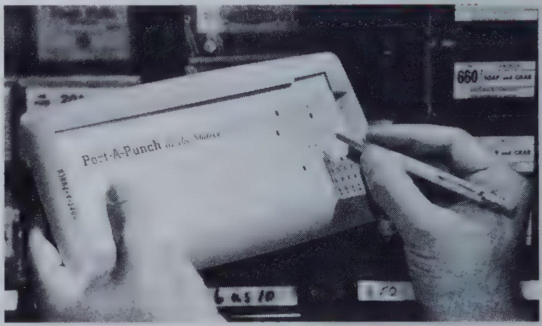
polystyrene

Dow technology has kept abreast of new developments in the design and manufacture of molded plastic parts by developing a wide range of versatile polystyrene formulations. There are now general purpose Styron materials with improved molding and extrusion properties, while the regular grades continue to be the standard of the industry. Special high impact formulations with greater heat resistance have been developed, and Styron Verelite, in two special formulations for molding and extrusion, adds excellent light stability to the outstanding list of Styron properties. For jobs demanding low moisture absorption, high dimensional stability, transparent or opaque color, easy moldability . . . look first to Styron. It can be extruded, vacuum formed, calendered and injection molded.

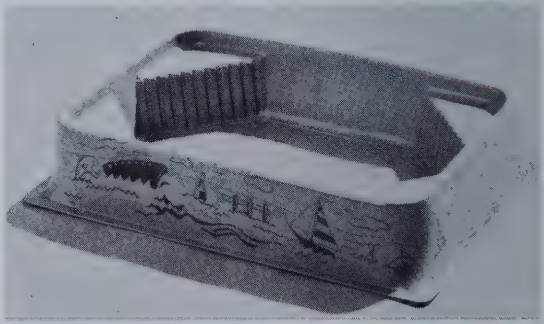

Abacus


Steak tenderator housing

Rigid food container


Inventory reporting unit

Television cabinet


Back yard play pool

PROVED IN USE FOR

Table legs

Refrigerator parts

Tackle boxes

Automobile parts

Wall tile

Housewares

Camera components

Lighting louvers

Radio cabinets

Vials

Containers

Photo developing tanks

Scale models

Appliance housings

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and many others

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Dow polyethylene is now available in a complete range of densities which make possible an almost infinite variety of property combinations. And, its complete uniformity means more profitable processing, fewer rejects and greater economy in quality output. Continuing research in this comprehensive polyethylene family is gaining momentum and has already contributed to the development of new and better products. A few representative products now being made with various Dow polyethylene formulations are shown here. For more information on the most complete line of injection molding and extrusion polyethylenes in the industry, write for technical literature.

Lace-work bag

Minnow bucket

PROVED IN USE FOR

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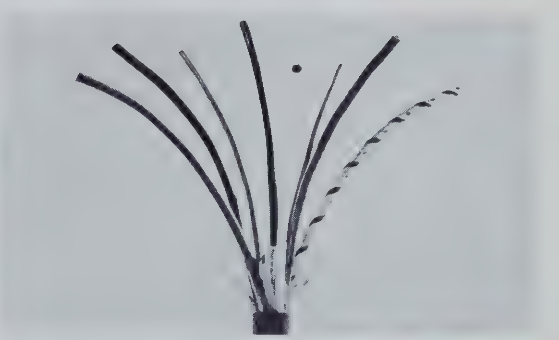
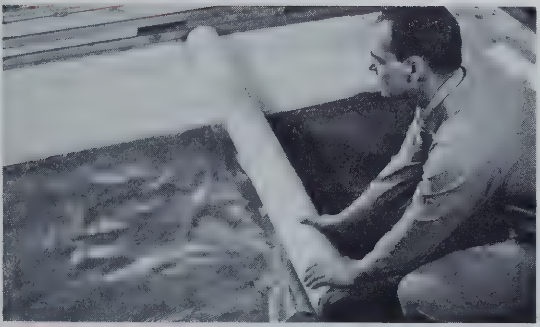
- Wire covering
- Cable covering
- Packaging film
- Closures
- Housewares
- Toys
- Pipe
- Industrial parts and components
- Food packaging materials
- Fitments and lids

Industrial pipe


Wire coating


Moisture-vapor barrier

Litter Basket

GENERAL CHARACTERISTICS: Uniformity with excellent processability, free-flowing granulations for constant feed, clarity, high finish, excellent stress crack resistance, superior drop impact properties, good aging.

PVC RESINS

polyvinyl chloride

Uniformity, cleanliness and ease of fabrication are the three outstanding features of Dow PVC Resins. Four specific resins provide all the properties you need for special and general purpose formulating. At Dow, resources and polymerization experience date back to the infancy of thermoplastics, and research continues to develop new and better resins to meet today's needs. You can specify Dow PVC Resins and know you're getting quality materials.

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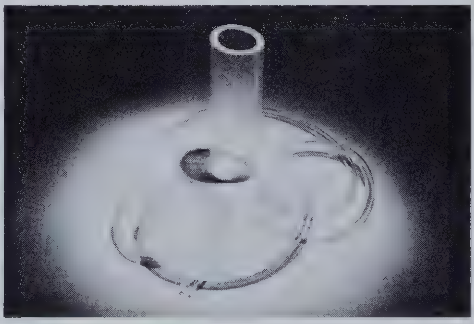
GENERAL CHARACTERISTICS: Superior cleanliness, greater plasticizer absorption, wide choice of plasticizers possible, free flowing in dry blend processing, shorter blending cycles, faster extrusion rates, highest uniformity.

Automotive upholstery


Thick walled tubing

Cable covering

SARAN

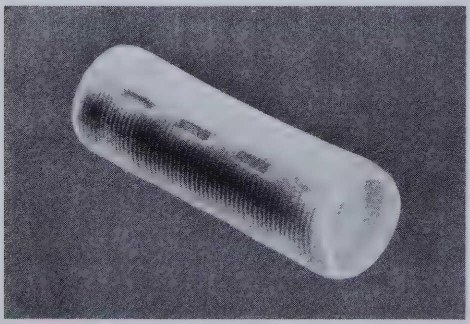
polymers and copolymers of vinylidene chloride plus similar materials

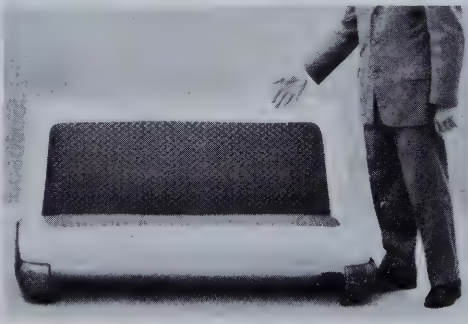
Saran, one of the most inert of all thermoplastics, offers an outstanding combination of properties. Combining toughness, flexibility and durability with a resistance to the abrasion and the corrosive action of most chemicals, Saran meets service requirements for many applications better than any other plastic material.

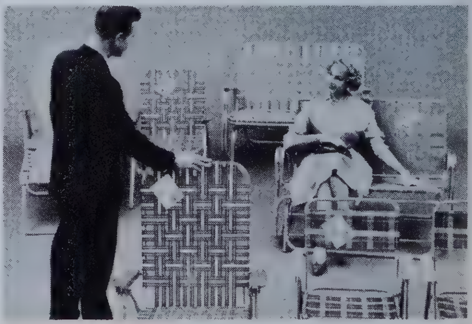
PROVED IN USE FOR

Auto seat covers and upholstery • Outdoor furniture webbing • Draperies • Carpeting • Doll hair • Bristles • Packaging film • Fittings and couplings • Pipe and pipe linings • Acid resistant filtering cloths • Window screening • Awnings and tapes • Paint gun atomizers

GENERAL CHARACTERISTICS: High tensile strength, excellent chemical resistance, easy cleaning, good resilience, excellent resistance to weathering, good color stability, will not support fungus growth, and is self-extinguishing.


Gasoline filter


Seat covers


Outdoor furniture

FROM THE DOW FAMILY OF THERMOPLASTICS

PELASPAN®

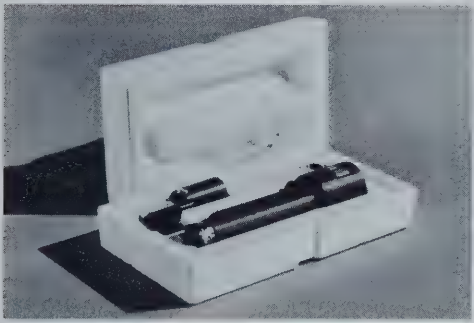
expandable polystyrene beads

To answer the need for a dependable foaming-in-place material, Dow developed Pelaspan, an expandable polystyrene sold in bead form. Pelaspan is an extremely versatile material which opens the door to many new and hitherto impractical foam applications. It can be bonded to metals, to itself and to other porous and nonporous materials. Available in regular and self-extinguishing formulations.

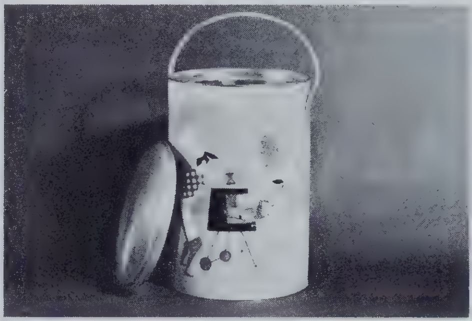
PROVED IN USE FOR

Thermal insulation • Buoyancy applications • Sandwich panel cores • Packaging • Shock absorption • Toys • Novelties • Displays • Low density filler • Refrigerator components

GENERAL CHARACTERISTICS: Low thermal conductivity, low water absorption, low water vapor transmission, high strength-to-weight ratio, variable fabricated densities, no odor.



Electronic component package



Portable cooler

Sandwich construction

ETHOCEL

an ethylcellulose molding compound

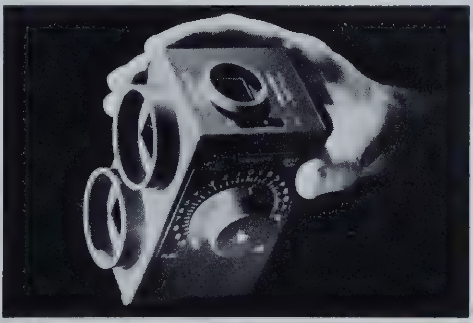
Ethocel, the finest thermoplastic molding material available, offers toughness, excellent dimensional stability and chemical resistance, and high impact strength from 40°F. below to 200°F. above. Takes extreme shocks. Ethocel molds easily to make large, single-unit moldings practical. It comes in a variety of formulations to answer your needs.

PROVED IN USE FOR

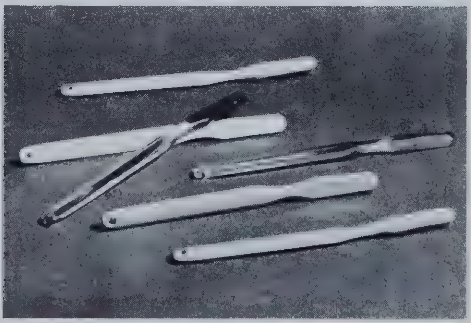
Football helmets • Safety headgear of all types • Toothbrush handles • Luggage • Refrigerator and freezer parts • Vacuum cleaner parts • Table edgings • Sheet for vacuum forming • Cigar holders • Chair arm rests • Floor sweepers • Military uses

GENERAL CHARACTERISTICS: Tough, withstands impact over wide temperature range, odor free, dimensionally stable, resistant to many chemicals, wide color range, light weight, self-lubricated formulations available.

Control wheel



Transit



Toothbrush handles

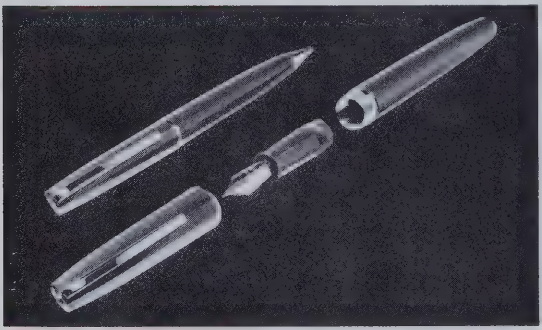
FROM THE DOW FAMILY OF THERMOPLASTICS

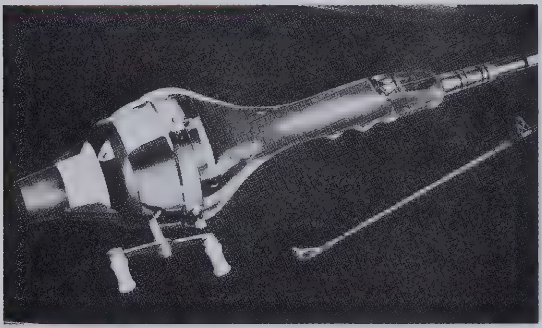
TYRIL®

a copolymer of styrene acrylonitrile

Now in its third year of commercial production, Tyril has proved its worth in applications ranging from batteries to packaging. Tyril is a rigid thermoplastic with exceptionally high strength and toughness. Resistance to crazing due to its high critical elongation means long life for molded parts. Tyril has improved dimensional stability which makes it ideal for molding close fitting working parts. Its resistance to acids, bases, salts, oils, waxes, soaps, food stains and many solvents including aliphatic hydrocarbons is remarkable, making it a valuable tool throughout industries where these chemicals are a problem. It is exceptionally easy to mold.

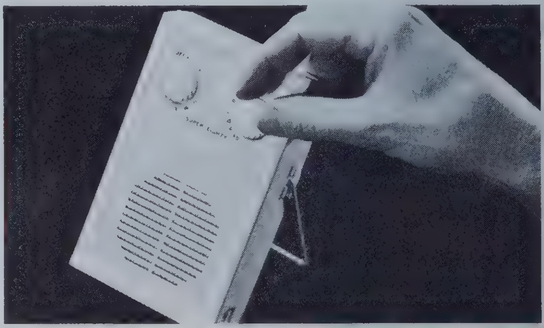
Pitcher and tumblers


Pen and pencil barrels

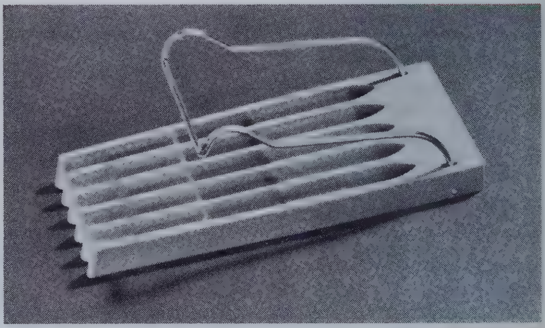

Fishing rod

PROVED IN USE FOR

- Automobile parts
- Refrigerator components
- Nozzles
- Tumblers
- Closures
- Medical equipment components
- Brush blocks
- Batteries
- Telephone components
- Film
- Rigid food containers
- Pencil and pen barrels
- Bristles and filters
- Appliance housings
- Camera components
- Monofilaments


Transistor radio housing

Milk dispenser


Trousers rack

GENERAL CHARACTERISTICS: High rigidity, resistant to chemical attack, high critical elongation, tough, wide range of transparent and opaque colors, excellent moldability, receptivity to decorative colors and finishes.

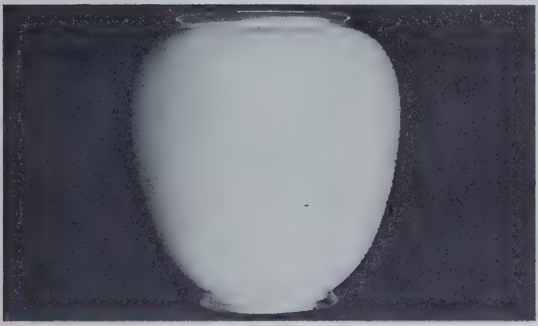
FROM THE DOW FAMILY OF THERMOPLASTICS

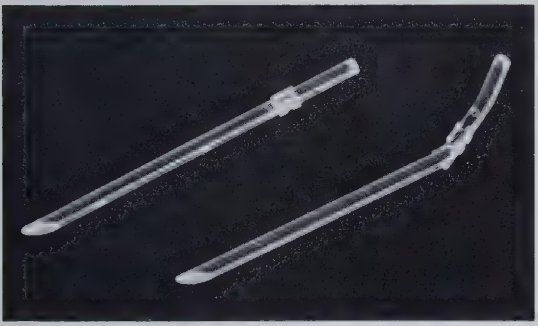
ZERLON*

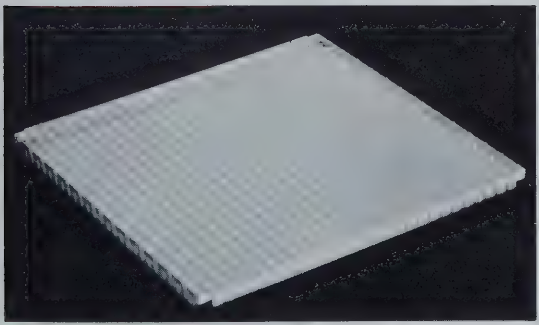
a copolymer of methyl methacrylate styrene

Zerlon is the newest, and from all indications one of the most exciting, of the Dow family of thermoplastics. Following its introduction early this year, requests for samples and technical information on this unique methyl methacrylate styrene copolymer deluged Dow headquarters. Zerlon offers, for the first time in the industry, a combination of features that promises to open up many new markets for plastic products. It has outstanding fabrication advantages, and combines optical clarity with weatherability heretofore unavailable in Dow materials. Thoroughly field tested, Zerlon can effect economies in equipment and fabrication as well as in material costs.

*Trademark


Streetlight globe


Light piping tubing


Fluorescent lighting grid

PROVED IN USE FOR

Automobile components

Appliance components

Displays

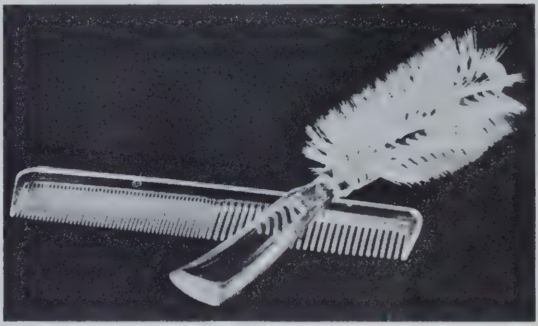
Outdoor signs

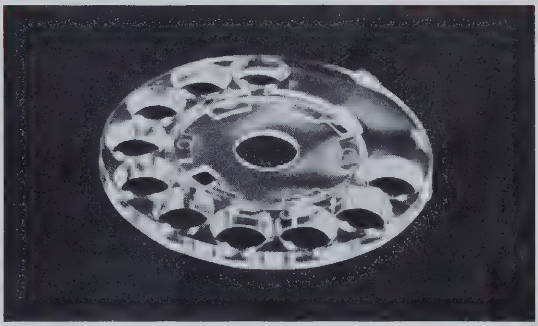
Specialty items

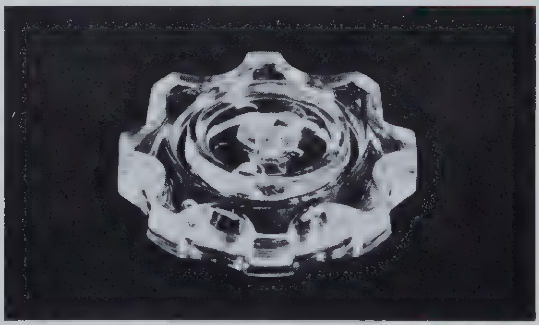
Novelties

Decorative products

Boat windshields


Comb and brush


Telephone dial


Control knob

GENERAL CHARACTERISTICS: Outstanding ease of fabrication, optical clarity, excellent weatherability, high tensile strength, high elongation, toughness, resistance to heat.

THE MOST COMPLETE LINE OF THERMOPLASTICS

in the industry

Eight basic plastic materials and dozens of special formulations assure you the right material for the job.

As the industry leader in the development and refinement of materials, Dow will continue its efforts to develop new and better materials. As a Dow customer, you know you're always getting the most up-to-date materials available.

Dow services and facilities assure speedy delivery, minimum inventories, convenient warehousing, prompt sales attention. What's more, technical service laboratories are maintained in Michigan, Texas, California and Connecticut to help customers solve production problems and assist in new product development work.

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THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Ion exchange resins

By Charles T. Dickert[*]

The first synthetic organic ion exchange resins appeared on the chemical scene over 20 years ago. Today they have completely overshadowed the older inorganic exchangers and, as a result, a phenomenal growth involving the whole field of ion exchange has taken place.

The reasons for this growth are: a much wider variety of exchange groups can be introduced into the organic resins; differing degrees of porosity can be obtained at will; and the organic exchangers have greater chemical and physical stability which are manifested under extremes of acidity and alkalinity.

Ion exchange resins may be classified as cation exchangers with either strongly or weakly acidic functional groups and anion exchangers which possess either strongly or weakly basic functional groups.

Ion exchange reactions

The important reactions of these resins are shown in the schematic equations below, in which "R" represents the insoluble organic resin skeleton to which the hydrophilic functional groups are attached.

Strong acid cation exchanger

Neutralization

$$RSO_3H + Na^+ + OH^- \leftrightarrows RSO_3Na + H_2O$$

Cation exchange

$$2\ RSO_3Na + Ca^{++} + 2\ Cl^- \leftrightarrows (RSO_3)_2Ca + 2\ Na^+ + 2\ Cl^-$$

Neutral salt splitting

$$RSO_3H + Na^+ + Cl^- \leftrightarrows RSO_3Na + H^+ + Cl^-$$

Weak acid cation exchanger

Neutralization

$$RCOOH + Na^+ + OH^- \leftrightarrows RCOONa + H_2O$$

Cation exchange

$$2\ RCOONa + Ca^{++} + 2\ Cl^- \leftrightarrows (RCOO)_2Ca + 2\ Na^+ + 2\ Cl^-$$

Neutral salt splitting

$$RCOOH + Na^+ + Cl^- \rightharpoondown$$

Virtually no reaction.

Strong base anion exchanger

Neutralization

$$RN^+ (CH_3)_3OH^- + H^+ + Cl^- \leftrightarrows RN^+ (CH_3)_3Cl^- + H_2O$$

Anion exchange

$$RN^+ (CH_3)_3Cl^- + 2Na^+ + SO_4^= \leftrightarrows [RN^+(CH_3)_3]_2SO_4^= + 2Na^+ + 2Cl^-$$

Neutral salt splitting

$$RN^+ (CH_3)_3OH^- + Na^+ + Cl^- \leftrightarrows RN^+ (CH_3)_3Cl^- + Na^+ + OH^-$$

Weak base anion exchangers

Neutralization

$$RN^+H_3OH^- + H^+ + Cl^- \leftrightarrows RN^+H_3Cl^- + H_2O$$

Anion exchange

$$2RN^+H_3Cl^- + 2\ Na^+ + SO_4^= \leftrightarrows (RN^+H_3)_2SO_4^= + 2\ Na^+ + 2\ Cl^-$$

Neutral salt splitting

$$RN^+H_3OH^- + Na^+ + Cl^- \rightharpoondown$$

Virtually no reaction.

All of the many types shown are capable of entering into the neutralization reaction, but this reaction is reversible by hydrolysis in the case of the weak acid or weak base resins. Second, all of the resins will exchange ions of one species for others of the same species, excepting the special cases of hydrogen and hydroxide ions. The reversibility of these reactions by changing the concentration of the solution contacting the resin is, of course, the feature that permits the economical employment of these materials in so many processes. Third, only strong acid and base exchangers can "split" neutral salts, liberating in the one case a strong acid, in the other case setting free a strong alkali.

Other fundamental chemical properties not shown by the equations above include the fact that ion exchange resins show different affinity for adsorbing different ions. Thus, for cation exchangers, ions of higher valence tend to replace ions of lower valence ($Th^{4+} > Al^{3+} > Ca^{++} > Na^+$) and ions of higher atomic number tend to replace ions of lower atomic number ($Cs^+ > Rb^+ > K^+ > Li^+$).

Another important property of ion exchange resins is their porosity. In order to make full use of all the functional groups in a resin particle, it is obviously necessary to have pores large enough to permit the ions to diffuse into them.

Manufacture

The most important synthetic ion exchange resins are made by copolymerizing styrene with a cross-linking agent such as divinylbenzene (DVB) and subsequently reacting this skeleton with agents that will introduce the desired functional groups, or by copolymerizing compounds already containing functional groups with cross-linking agents. Examples of the first procedure are sulfonation of the styrene DVB skeleton to yield cation exchangers, or chloromethylation followed by amination to yield anion exchangers. Examples of the second procedure are copolymerization of methacrylic acid with DVB or of maleic anhydride and styrene with DVB to yield weak acid cation exchangers.

There are still available some very important ion exchange resins based on phenol-formaldehyde, amino-benzene-formaldehyde, or nitrogen heterocycle-formaldehyde condensates.

In all cases, control of the degree of porosity is possible. With the vinyl polymers, this is accomplished by regulating the amount of cross-linking agent; with the condensates, by the amount of formaldehyde used; or inert extenders can be added to both.

Still another important consideration with ion exchange resins is particle size and size distribution since these affect the rate of exchange and the hydraulic properties of the system.

Equipment and operation

By far the most general use of ion exchange resins is in column operation. That is to say, the resins are employed as fixed beds in suitable containers and are contacted by the solution that is to be treated as it flows through the bed.

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[*] Rohm & Haas Co., Washington Square, Philadelphia 5, Pa.

References were prepared by the editors.

After the resin has adsorbed all of the ions that it is capable of adsorbing under the conditions employed, it is regenerated by passing through the bed a more concentrated solution of a reagent that will return it to its original ionic form. Ion exchange processes are carried out on a laboratory scale in pipets, burettes, or small-diameter columns, and on an industrial scale in tanks which are of sufficient size to hold several hundred cubic feet of ion exchange resin.

A continuous ion exchange process is also possible, using moving beds of resin which are transferred by means of eductors from the exhausting chamber, and recycled, but this is a complex and expensive operation.

In certain batch ore-treating processes, baskets of large-particle-size resin are dipped into slurries (or pulps) of the finely divided ore suspended in a leaching solution until the resin is saturated with the desired ion. The baskets are then removed and regenerated in another batchwise step.

Applications

Water conditioning: The largest volume of ion exchange resin is currently being used in water conditioning. In general terms, water conditioning involves a) softening water supplies to make the water satisfactory for the home and industry and b) de-ionization of water used for industrial production of high purity chemicals and for generation of electrical power.

De-ionization is the removal of all ions present in the water through the use of cation and anion exchangers contained in two successive separate beds (columns) or in a Monobed (mixed bed). A cation exchanger in the hydrogen form removes all cations while a strong base resin in the hydroxide form removes all anions, including soluble silica. A highly porous strong base resin will remove organic material so that water of extremely high purity can be produced.

The use of de-ionized water for the production of chemicals on an industrial scale is becoming more and more important each year. As an example, the production of pentaerythritol involves first synthesizing formaldehyde by reacting methanol with de-ionized water in the vapor phase under oxidizing conditions. The formaldehyde vapor produced is absorbed in de-ionized water. Some formic acid is also formed in this reaction but it is removed by passing the formaldehyde solution through an anion exchange resin. Pentaerythritol produced from the purified formaldehyde contains a sodium formate reaction impurity which is removed by passing the pentaerythritol through cation and anion exchange resins.

Recovery of valuable metals: Ion exchange resins have been indispensible in the recovery of valuable metals such as uranium from ores containing the metals in very low concentrations. Some of the metals form anionic complexes which may be concentrated and purified by first adsorbing on an anion exchange resin and then eluting or recovering with a simple salt solution. Other metals do not form anionic complexes but remain as cations. These are concentrated and purified by adsorbing on a cation exchange resin and then eluted by using an appropriate solution. Some metals which are difficult to separate, such as the rare earths, are not only purified and concentrated by the cation exchange resins but are also fractionated so that each may be recovered in purities approaching 100 percent.

Food processing: In some cases the use of ion exchange resins for processing foods is very similar to water conditioning. As an example, sugar solutions which normally contain appreciable ash can be purified by removing the ionized solids with a de-ionization process in which cation and anion exchange resins are employed. Anion exchange resins are also used to remove high molecular weight organic compounds which tend to impart color to sugar solutions.

Pharmaceutical: Powdered ion exchange resins are being used in more and more drug preparations each year. These resins can be used as antacids, for ulcer therapy, for controlling cardiac edema, and for treatment of diseases where sustained release of specific drugs is desired.

Micropowdered ion exchange resins or combinations of several ion exchange resins can be used in skin creams, lotions, and powders as a means of maintaining the normal acid mantle factor of the human skin. Some preparations are useful as anti-perspirant deodorants.

Larger particle size ion exchange resins are used commercially by pharmaceutical companies for the recovery and purification of valuable products, such as streptomycin.

Analytical: In analytical chemistry, the hydroxide form of anion exchange resins and the hydrogen form of cation exchange resins are most useful because each anion adsorbed by the anion exchange resin or each cation adsorbed by the cation exchange resin must remove an equivalent amount of hydroxide or hydrogen ions, respectively. These ions appear in the effluent and can be titrated using an acid-base indicator. Smaller particle size ion exchange resins are finding increased utility for chromatographic separations. These fine particle size resins may be used in columns or in papers for the separation of amino acids and also for a host of other groups of compounds which possess similar properties.

References

Consult the Subject Index for additional information on ion exchange resins. For sources of ion exchange resins, consult the Directory Index, p. 1078.

"Ion exchange resins," MODERN PLASTICS *31,* 228 (Feb. 1955).

"Studies of a cross-linked polyethyleneimine ion-exchange resin," by E. J. Shepherd and J. A. Kitchener, J. Chem. Soc. *1957,* 86 (Jan.).

"New uses for ion exchange resins," by R. M. Wheaton, Chem. Eng. Prog. *52,* 428 (Oct. 1956).

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Isocyanate resins

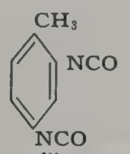
By Leslie M. Faichney*

Ten years ago this encyclopedia mentioned polyurethanes briefly, stating that "the Air Force has recently shown interest in a polyurethane foam material . . ." Since that time, and particularly in the past five years, isocyanate resins, upon which urethanes are based, have grown far beyond the most optimistic market forecast of ten years ago.

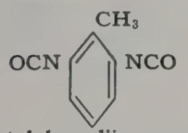
Chemistry

When isocyanates are reacted with "active" hydrogens such as occur in polyols—glycols, polyesters, polyethers, or castor oil, for example—they form addition polymers, among which is urethane.

Tolylene diisocyanate, one of the family of diisocyanates from which urethane resins are made, exists mainly in two isomeric forms.



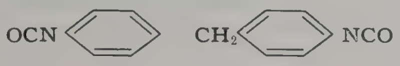
2,4 tolylene diisocyanate



2,6 tolylene diisocyanate

The normal isomer ratio, starting with toluene and subsequently nitrating, reducing, and phosgenating, is about 80% 2,4 tolylene diisocyanate and 20% 2,6 tolylene diisocyanate. It is the least costly of the commercial diisocyanates. The 65:35 isomer ratio, which was the first to be introduced in this country, utilizes ortho-nitrotoluene, a byproduct from the preparation of para-nitrotoluene. The tolylene diisocyanates are liquids at room temperature.

Another commercial diisocyanate being consumed in increasing volume is diphenylmethane 4,4′-diisocyanate. Solid at room temperatures, this diisocyanate is used for making coatings and for other types of noncellular urethanes.



Diphenylmethane 4,4′-diisocyanates

If water is present, even in very small amounts, it will react with a diisocyanate to form disubstituted ureas and carbon dioxide. When a polyol, together with some water, a catalyst, and an emulsifier is mixed intimately with the required amount of diisocyanate, polymerization and gas-forming exothermic reactions proceed at the same time, yielding a gel structure in which the evolved gas is trapped. The cured material is a urethane foam.

The molecular structure of the polyol determines whether the urethane foam will be flexible or rigid. Long chain polyols with widely spaced reaction sites will give flexible foams, whereas branched polyols having closely spaced cross-linking sites will give rigid foams.

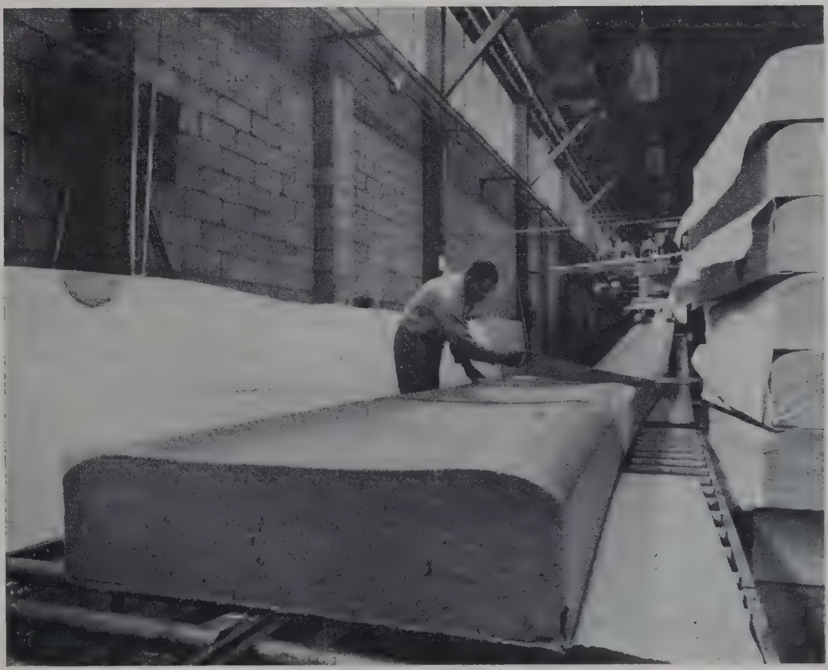
More recently, auxiliary physical blowing agents have been used in conjunction with, or as total replacement for, the carbon dioxide produced by the water-diisocyanate reaction. One such agent is a volatile halocarbon which has found extensive use in blowing rigid foams, and has shown promise even for flexible foams.

Flexible foams

The flexible urethane foam market is presently the largest outlet for isocyanate resins and one-shot polyether foams can now be made commercially.

Polyester flexible foams could always be produced by the one-shot method and it was these foams that aroused early interest in the urethane field. They still offer some outstanding advantages—high tensile and tear strengths and high load-bearing capacity at low density. Disadvantages include a tendency to deteriorate under conditions of high humidity, a so-called "plateau" in the stress-strain curve

TYPICAL OF NEW HIGH-SPEED PROCESSING TECHNIQUES being developed for urethane foam based on isocyanate resins is this 120-ft. long production line. The continuous process used transforms liquid resin mixture into a 1200-lb. slab of urethane foam in about 30 minutes. (Nopco)



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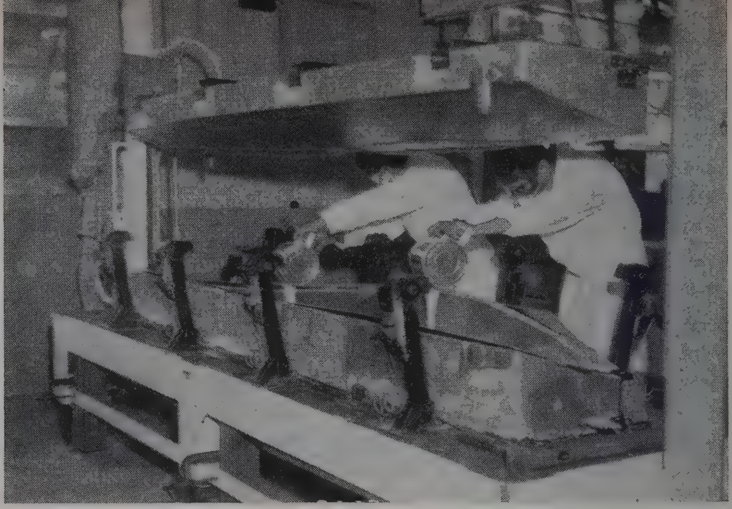
* Allied Chemical Corp., National Aniline Div., 40 Rector St., New York 6, N. Y.

References were prepared by the editors.

MAJOR MARKET FOR THE FLEXIBLE UREHANE FOAM is still in cushioning applications. Heritage Furniture Co. (above) is only one of the 200 manufacturers now using foam cushioning in their products. (Allied Chemical Corp.)



. . . FOR THE FOAM-IN-PLACE RIGIDS, industrial applications stand out. To provide a vibration dampening surface for an aircraft fairing section, for example, the hand-mixed formulation is poured into a heated mold, which is then clamped shut. Foam fills cavity in 15 sec., is cured 3 hr. to obtain maximum properties. Material has 5 lb./cu. ft. density. (American Latex)

which is undesirable for comfort cushioning, and, of course, the higher cost of the raw materials which are used.

Polyether flexible foams could not initially be made by the one-shot procedure because of the lower reactivity of the hydroxyl groups of the polyether resin. A cooking cycle or prepolymerization was necessary to react these hydroxyl groups with the diisocyanate before addition of water to make the foam. However, the resultant foam, compared with material based on polyester, offered improved resilience, better hydrolytic stability, and a much lower material cost.

Two general approaches have been developed for making one-shot polyether foams. These are as follows:

The first is to retard the water-diisocyanate reaction. In prepolymers, the water is withheld until the foaming step. A modified one-shot foam has been prepared by introducing water into a continuous prepolymer system after the polymer is formed and just prior to foaming.

The second approach is to accelerate the urethane reaction by use of special catalysts such as potassium hydroxide, triethylene diamine, and more recently, such metal organic compounds as dibutyltin dilaurate.

Flexible foams are used extensively in the automotive industry as topper pads and crash pads and in the furniture industry for comfort cushioning. Other uses include clothing interlining, rug underlay, wall tile, and many novelty items.

Rigid foams

Rigid foams blown with a halocarbon, particularly trichloromonofluoromethane, the so-called Refrigerant 11, exhibit thermal insulation properties about twice as good as any previously reported commercial material. K factors of 0.12 to 0.15 can easily be attained at low densities (1.5 to 2.0 lb. cu. ft.).

The blowing agent can be dissolved in the isocyanate component of the rigid foam system or can be introduced as a third component at the mixing head. As the polyester-diisocyanate reaction proceeds, the heat of reaction volatilizes the intimately dispersed blowing agent to create a uniform fine closed cell structure.

These properties indicate the usefulness of rigid urethane foam in refrigerators, refrigerated trucks and railway cars, cold storage rooms, and any application where good thermal insulation is required.

Polyethers have largely displaced polyesters for use in flexible foams, and they promise to do the same in rigid foam usage. Polyethers based on tri- and quadrifunctional building units, together with cross-linking agents, are producing foams with satisfactory appearance and properties. Cost is an important consideration in evaluating such formulations.

Rigid foams lend themselves readily to application by spray technique. Internal-mixing guns give a uniform foam equal in properties to many machine-mixed foams. Applications such as insulating process tanks, walk-in freezers, and home insulation, suggest themselves for this technique, which allows sufficient saving in labor to more than compensate for a higher material cost over many conventional insulants.

By slight modification, the same type of gun can be used for flexible foams.

Even "physically" blown foams have been sprayed, although with greater difficulty than the conventional water-diisocyanate blown foam.

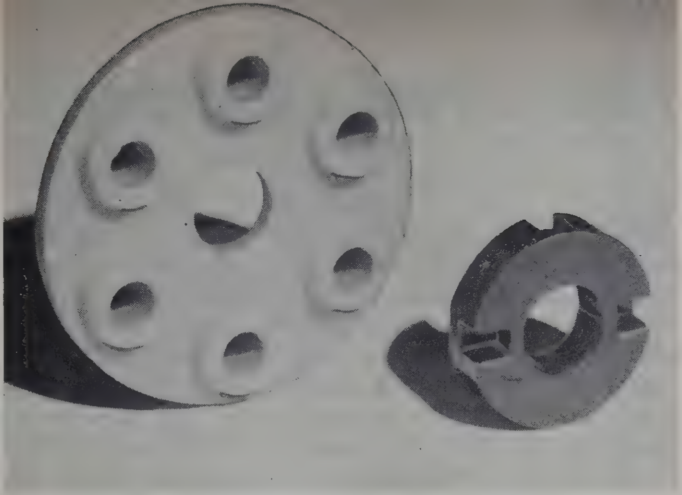
Coatings

The isocyanate coatings market has shown a considerable gain during the past year. The greatest increase has occurred in the leather finishes field. Patent leather, in particular, makes good use of the high gloss and high abrasion resistance that characterizes urethane coatings.

These coatings can be divided into two general groups: isocyanate reactive coatings which depend upon the reaction between isocyanate and hydroxyl groups for curing, and diisocyanates combined with unsaturated drying oils which cure by conventional means.

Isocyanate reactive coatings are formulated from polyesters, poly-

. . . STILL A THIRD AREA OF USE for urethane is in protective paints here being applied to a filter press frame to protect it against attack by acids and alkalies. Final thickness of coat is 5 to 8 mils. (Allied Chemical Corp.)



. . . AND FINALLY, URETHANE ELASTOMERS are beginning to show promise for such applications as silent-running gears which require no lubrication for effective performance and power train components that adjust to such stresses as might be caused by such factors as shaft misalignment and stop-and-go forces. (Mobay Chemical Co.)

ethers, or other polyols and diisocyanates or diisocyanate adducts. These components must be kept in separate containers until just prior to use—the so-called "two-can" system.

The reactive isocyanate groups can now be temporarily blocked with phenol and the components stored in one can. Then when the coating is applied and baked, the phenol splits off and the isocyanate is once again available for the more stable urethane reaction. This system is used for wire coatings.

Other two-can coatings based on castor oil/tolylene diisocyanate (TDI) and castor oil/diphenylmethane diisocyanate (MDI) have proved serviceable under harsh chemical conditions. Of the two, the MDI based coatings have the better chemical resistance. Fillers like graphite, portland cement, and antimony oxide have been used to impart improved toughness and chemical resistance.

Urethane drying oils have been on the market for a couple of years, and are finding acceptance in coatings on a cost/performance basis. They are made like oil modified alkyds, with the diisocyanate replacing some of the dibasic acid. They offer several advantages: fast drying time, unusual durability and hardness, and good weathering resistance.

Elastomers

The commercial use of urethane elastomers in products such as solid industrial tires, gaskets and O-rings, printing rolls, vibration mountings, encapsulants, and classified military applications, continues to increase.

The uncured elastomers are available as solid rubber similar to a crude natural rubber, or as liquid components.

Solid storable urethane rubbers can be processed on conventional rubber equipment, mills, calenders, extruders, etc., but have been rather slow in gaining acceptance.

The liquid polymers, on the other hand, are convenient to store and to mix. No costly equipment or high power consumption is necessary. Techniques for producing solid castings have already been worked out; fabricating is still in the experimental stage.

Raw materials are similar to those used for coatings (without the solvent) or for foams (without the gas-forming materials). Thus an infinite variety of properties is available of which abrasion resistance and chemical resistance are again outstanding.

Urethane elastomers appear to resist the damaging effect of radiation better than other commercially available elastomers.

Adhesives

Urethanes adhere tenaciously to wood, vinyl, leather, and such smooth-surfaced materials as glass and ceramics. For example, aluminum - to - aluminum bond strengths of greater than 2000 p.s.i. in shear have been obtained.

Isocyanates have been used for some time in conjunction with rubber cements to improve adhesion to such synthetic fibers as nylon.

References

Consult the Subject Index for additional information concerning isocyanate resins and polyurethanes. See also the Adhesives and Foamed Plastics Charts. For sources of isocyanate resins, see Directory Index, p. 1078.

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Natural resins

The natural resins constitute a continuous series of solid, nontoxic, film-forming gums varying over a broad range of solubilities and hardness. Named for their source of origin, in most cases, they are classified into four major groups, as follows: 1) Damars; 2) East Indias: batu, black, pale; 3) Copals: manila, pontianak, kauri, congo; and 4) Miscellaneous: accroides, elemi, mastic, sandarac.

Almost all of the natural resins are simply cold-cut in solvents where they are generally compatible with substances soluble in the same materials. Many of the resins are oil-soluble in their raw state, while others (congo, black and pale East Indias, kauri) are prerun at high heats. A range of grades is available in all of the varieties.

Damars are versatile resins, having adhesion, depth of gloss, color, gloss retention, miscibility, and resistance to scuffing, greases, and cold checking. "Dewaxed" Damar is a lacquer resin.

East Indias are related to the Damars. Batu is a high-melting-point resin with greater viscosity, water resistance, and weather resistance. It has fast solvent release, and compatibility with stearic acid and a wide range of oils, waxes, resins, asphalts, pitches, chlorinated rubber, and cellulose derivatives. Uses include varnishes, inks, adhesives, and composition products. Black East India makes an opaque varnish that dries to a light color. It provides tough varnishes for metals and wood with water resistance, adhesion, and flexibility. Pale East India yields greater control of sheen. Its resistance to temperature changes and water makes it useful in special-purpose varnishes.

Copals: Manilas are broadly used in alcohol solutions for varnishes, printing inks, adhesives, liquid waxes, compositions, and specialty products; gloss, color retention, and flexibility give it broad usage. *Pontianak* is similar to the manilas but of higher melting point. *Kauri* has long been used as a basic varnish resin. Certain grades are alcohol-soluble. This is a fossil resin. *Congo* is insoluble in its original state. Processed, it can be adapted to broad uses in varnish coatings in which toughness, flexibility, adhesion, color, and gloss retention are desired. Metal coatings, floor varnishes, enamels, wrinkle finishes, and furniture varnishes are some of its outlets.

Accroides (red, yacca) is a specialty resin with thermosetting qualities. Its red color is inseparable. *Elemi* is a plasticizing resin used in varnishes, lacquers, caulking compounds, and specialty coatings. *Mastic* and *sandarac* are specialty resins used in artistic fields.

Amber: This yellowish, transparent-to-translucent fossil resin is derived from an extinct conifer. It takes a polish well and is the hardest known natural resin. However, it is brittle and breaks with a conchordal fracture.

Shellac: This natural resin is produced by tree lice (*Taccardia lacca*) found in Asia. Shellac exhibits characteristics of both thermoplastic and thermosetting types of binders, retaining its thermoplasticity for a long period when heated. Heat-curing increases the mechanical and electrical strength of the material.

Rosin: This product of pine tree exudations consists largely of abietic acid, together with other complex terpenic acids and esters. It has not been used extensively in molding compositions because of its low softening point and brittleness.

Vinsol[1] is another product of the steam distillation process by which naval stores are extracted from the wood of the long-leaf Southern pine. It is an ideal modifier for most natural and synthetic resins. High-melting materials or thermosetting condensates are produced by reacting the resin with aldehydes. It is soluble in alcohols, esters, cyclic hydrocarbons, and chlorinated solvents, possesses high dielectric strength, a low power factor even at high temperatures, and has the ability to withstand high-voltage electrical impulses.

Asphalts: These are naturally-occurring hydrocarbon complexes, termed bitumens, which are insoluble in water, but soluble in carbon disulfide and benzene. The amorphous brownish-to-black mixtures range from mobile fluids to hard, friable solids. Asphalts can also be processed to yield such properties as good dielectrics, and resistance to moisture, acid, alkali, and most chemicals.

Cashew resins: The cashew nut is obtained mainly from India. The heat-reactive-type resins formed by condensation of the cashew phenols with aldehydes are available in the form of mobile liquids, viscous liquids, powdered fusible solids, granular infusible solids, and rubbery infusible solids. Typical applications are adhesives, phenolic resin plasticizers, potting compounds, protective coatings, rubber compounding, and synthetic drying oils of an extreme degree of alkali resistance and in automotive and other brake linings.

References

Consult the Adhesives and Coatings Charts for information on properties and trade designations. For sources of natural resins, see Directory Index, p. 1078.

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[1] Trademark of Hercules Powder Co.

Nylons (polyamides)

Basically, nylons are polymeric resins, formed by the condensation of dibasic organic acids with diamines into linear chains containing amide groups. They were developed in the classic researches of W. H. Carothers and introduced on the market in 1938 in the form of bristles and hosiery fibers. The inherent properties of the material, however, such as strength, toughness, ability to withstand high temperatures, abrasion resistance, and good chemical resistance, made it quickly apparent that a potential existed as an industrial molding powder. Consumption of nylon powders for this purpose has increased considerably over the past few years.

Table I, p. 126, lists the various types of present-day commercial nylons, showing the chemical raw materials used to make them and the properties that are imparted by them to the different nylons listed.

Within the wide range of nylons available, the three most important types of nylon are nylon 6/6, nylon 6, and nylon 6/10. Nylon 6/6 (so-called because both the acid and amine used in making it contain 6 carbon atoms) is the most common and oldest type of nylon. Nylon 6, a newer material, is a polymer made by opening the ring of caprolactam, a 6-carbon condensed amide. Some of the nylon grades possess considerably higher impact strength, are more flexible, and have better low temperature properties than nylon 6/6; however, these attributes are attained through a sacrifice of stiffness, abrasion and heat resistance, and creep properties. Other nylon 6 grades are comparable to nylon 6/6 in both physical properties and molding cycles required.

In the manufacture of the third major type of nylon, 6/10, sebacic acid is substituted for the adipic acid component to yield a softer, more resilient polymer with lower water absorption and better wet stiffness.

Over-all, however, the common 6/6 and 6 nylons have fitted into their important and rapidly growing uses because of a unique combination of desirable properties. They are stiff, strong, tough, light, abrasion-resistant, and self-extinguishing, have a low coefficient of friction, and are chemically and thermally resistant. Such properties, plus their ability to be accurately molded into intricate shapes, have fitted them for mechanical and other critical applications where they either replace less satisfactory or more expensive metal parts, or do jobs previously not possible. While wear properties are improved by lubrication, nylon moldings give excellent service with no lubrication under many service conditions and will frequently outwear corresponding metal parts. Nylon's chemical resistance is particularly valuable where electrolytic action corrodes metal parts, particularly where a bimetallic junction is involved. This property recommends nylon for various marine and oilfield applications.

Research work has also been going forward on various types of reinforced nylon molding compounds. One manufacturer claims to have developed a glass fiber-filled nylon with tensile strengths much greater than nylon in its virgin state. Another manufacturer reports on a molybdenum disulfide-filled nylon which offers high wear resistance, low dry-running friction, and excellent dimensional stability.

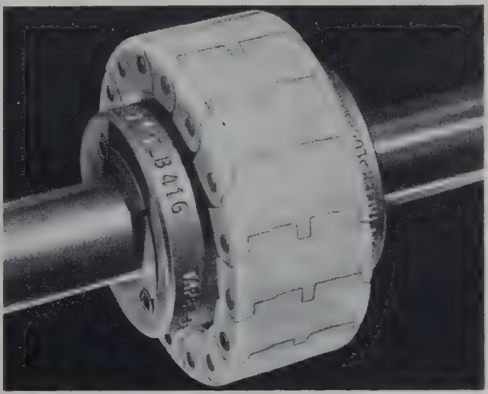
Processing nylon

Injection molding and extrusion are the usual methods of processing nylon; application from solution, compression molding, sintering, and other techniques are used for special purposes.

The common nylon 6/6 and 6 compounds can all be handled in conventional machines with little modification in equipment or procedures. When injection molding nylon 6/6, those differences that do exist can be attributed largely to the material's sharp melting point and low melt viscosity. This makes it necessary to fill molds as quickly as possible and the use of a booster is usually recommended. Nylon 6/6 also tends to freeze rapidly, contributing to rapid cycle and minimizing flash problems.

According to manufacturers of nylon 6, the material has a wider range of molding temperatures and a higher melt viscosity than molding-grade 6/6 nylon[1]. Furthermore, nylon 6 and certain modified compositions, such as Zytel 109[2] resin, have a lower melting point—contributing to greater ease in the molding of heavy sections without internal voids.

In extrusion-grade materials, both nylon 6/6 (e.g., Zytel 42[2]) and nylon 6 (e.g., Spencer 607) are available with higher melt viscosi-



NON-CORROSIVE molded nylon chain links, with stainless steel connecting pins, cost less than all-steel chains, wear longer, need no lubrication; are easy to assemble on sprockets to form long-lasting shaft couplings. (Photo, Morse Chain Co.)

This article is based on information supplied by E. I. du Pont de Nemours & Co., Inc.; Spencer Chemical Co.; Plastics and Coal Chemicals Div., Allied Chemical Corp.; Foster Grant Co., Inc.; The Polymer Corp. of Pa.; Firestone Plastics Co.; and Belding-Corticelli Industries.

Recent Developments and References were prepared by the editors.

[1] The extrusion-grade nylon 6/6s, however, are available with much higher melt viscosities than are available with the molding-grade nylon 6/6.

[2] Trademark of E. I. du Pont de Nemours and Co., Inc.

Improved flow properties in a new nylon formulation (*Zytel 101-2315*, E. I. du Pont de Nemours) generally permit increased productivity through faster molding cycles . . . lower molding temperatures are possible in many cases. A new hydrolysis-resistant resin (*Zytel FE-2281*) is recommended for applications requiring long service in hot water . . . A third new resin (*Zytel 109*) is a chemically modified 6/6 nylon offering a broader range of processing temperatures, lower injection pressure requirements, lower mold shrinkage, easy ejection, fast molding cycles.

Nylon molding material (*Fosta Nylon 62 A S K*, Foster Grant Inc.) is fast setting . . . more rigid than other nylon 6 materials . . . eliminates release problems. A modified type 6 nylon (*Fosta-Nylon 62A-SK*) has an extremely dense crystalline structure that offers better flow and faster setting . . . easier mold release . . . shrinkage, water absorption, and expansion uniform in all directions . . . greater stiffness and surface hardness. Also available is a molding grade of transparent nylon (*Fosta-Nylon BK-25T*) that offers complete transparency in thicknesses up to 0.060 inches . . . recommended for safety glasses, eye droppers, laboratory equipment, etc.

Ultra-high viscosity nylon compound (*Plaskon Nylon Extrusion Compound 8205*, Plastics & Coal Chemicals Div., Allied Chemical Corp.) for extrusion of large shapes . . . is also suited for blow molding.

Close-tolerance screws of molded nylon (Gries Reproducer Corp.) offer excellent electrical insulation . . . corrosion resistance . . . stability over wide temperature range . . . strength-to-weight ratio higher than steel . . . non-magnetic.

High-melt-viscosity nylon resin (*SN 607*, Spencer Chemical Co.) has extrusion characteristics similar to polyethylene . . . can be extruded in shapes and profiles that heretofore had to be injection molded or machined . . . can be used in film drawn down to ¼ mil that can be heat sealed. A new heat-stabilized injection molding resin (*SN404*) is available for applications in which retention of physical properties is required in parts subjected to elevated temperatures.

Record-size nylon cylinder, 21 in. long and weighing over 700 lb., is being produced (The Polymer Corp., Reading, Pa.) . . . with 16 in. outside diameter and 13 in. inside diameter . . . for use as roller coverings for embossing, coating, or similar processing of paper, textiles, artificial leathers, and other sheet materials. Prefabricated assemblies of nylon tubing (*Nylaflow*, The Polymer Corp.) now available to reduce costs of tubing systems . . . for hydraulic, lubrication, pneumatic and instrumentation, oil or fuel, chemical, and beverage lines . . . has a high burst pressure per unit weight, very long flex and vibrational life, excellent impact and abrasion resistance.

Large marine propellers for tugboats and trawlers are now being extrusion molded (by Auburn Plastics, Inc., for Columbian Bronze Corp.) out of nylon 6 materials. . .offer excellent corrosion resistance and strength. . .typical of the large pieces now being molded successfully of nylon.

ties than were heretofore possible —and consequently extruded nylon profiles, tubing, pipe, film and sheeting have started to find important new markets. Considerable activity has been noted in developing the use of nylon pipe in applications where the superior chemical resistance and heat resistance of the nylons is indicated. Extruded tubing has also made a place for itself in applications where resistance to pressure and vibration, combined with oil resistance, are important. Extruded film and sheet is at present in the development stage but should be made available shortly.

Nylon, in stock shapes and sizes, can also easily be machined. This type of fabrication is especially recommended for symmetrical components with multiple undercuts, internal threads, and longer inside diameters. The break-even point between molding or machining nylon parts is generally higher for smaller parts. For example, results on a part with a volume of 0.7 cu. in. indicate it would be more economical to mold than screw machine in quantities of 2000 and up, while a part 0.1 cu. in. did not become more economical to mold until quantities of 40,000 were reached.

An interesting technique in making nylon parts with improved wear characteristics and dimensional stability is cold pressing and sintering. By this method, specially processed finely divided nylon powders are pressed and sintered in a process somewhat similar to that used in powder metallurgy. The parts (e.g., Nylasint[3] nylon parts) can be sintered in oil to provide surface lubricity and an exceptionally low coefficient of static and dynamic friction. Various fillers, such as molybdenum disulphide and graphite, can be incorporated in concentrations as high as 80 percent. The parts exhibit superior crystallinity and have reduced thermal and hygroscopic expansion characteristics.

Nylon coatings for metals (e.g., Corvel[3] fusion bond finishes) are now available through the use of a process claimed to produce coatings retaining the prime mechanical characteristics of the nylon resin and its protective surfacing characteristics for such applications as rollers, bearings, degreasing racks, etc. In this process, the object to be coated is preheated and dipped into a bed of fluidized dry coating powders which, as the part is moved to and fro, impinge on the surface of the object and coalesce to form a uniform coating. The process was developed and patented in Europe; patents have now been issued in the U.S. and the process is available under license.

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[3] Trademark of the Polymer Corp.

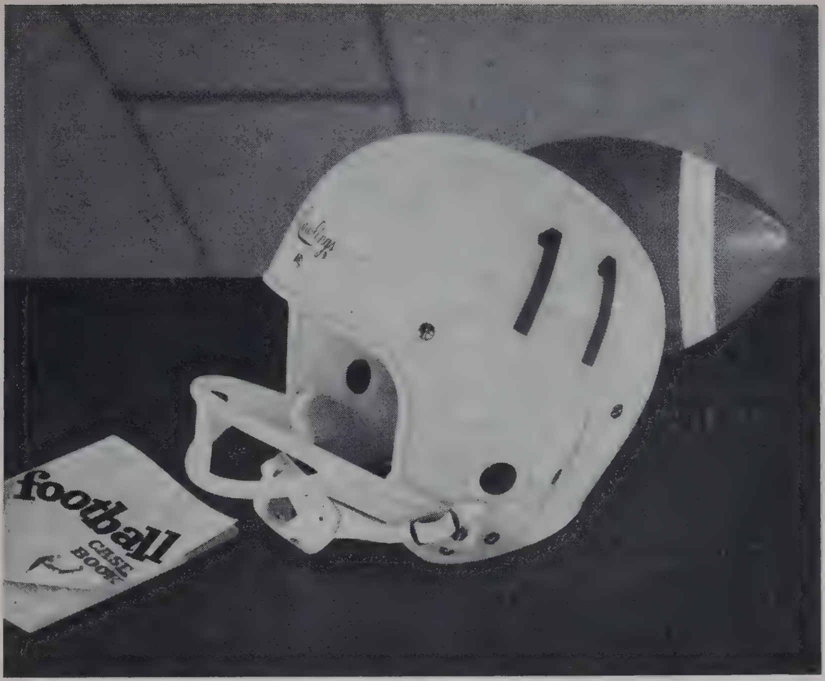
Drying

A major problem when handling nylons, particularly 6/6 and 6, is the fact that the materials are hygroscopic and will eventually absorb about 2½% moisture under average atmospheric conditions. However, more than about 0.3% moisture causes splayed moldings of reduced toughness. Therefore, every effort should be made to protect the molding powder from atmospheric moisture. If excess moisture has been picked up, the nylon should be dried in a dehumidified air oven or a vacuum oven before the molding operation. It is most important that the air taken in by the dryer be low in relative humidity.

Several after-treatments of nylon moldings are used to advantage. To relieve stresses, and thereby improve dimensional stability and toughness, moldings are often annealed at about 350° F. in an inert medium such as Glyco-wax S932. Furthermore, since 6/6 and 6 nylon, as mentioned above, will absorb about 2½% moisture under normal atmospheric conditions, it is often convenient to add about this much water by immersing in boiling water in order to improve the toughness of the molded piece.

Applications[4]

Nylon is more often used because of its combination of excellent properties than for any one single characteristic. These various properties have been exploited by a constantly expanding family of applications. The 6/6 and 6 nylons are particularly useful in molded mechanical parts. For example, nylon gears and bushings are being used in textile machinery, household appliances, calculating equipment, automobile speedometers, and windshield wipers, and in office and builder's hardware, to mention only a few. In addition to its other properties, nylon's excellent abrasion resistance in the absence of lubrication is particularly valuable where frequent oiling is either undesirable or inconvenient. For example, lubrication adequate for metal parts is often very undesirable in textile and food machinery, while in household appliances and fishing reels, the problem of lubrication is apt to be neglected by the ultimate user.



NYLON FOOTBALL HELMET is three times stronger than any other helmet and has resilience necessary to absorb blows. One-piece shell does not distort under playing field temperatures ranging from below zero to over 100° F. (Photo, Du Pont)

Other mechanical parts utilizing nylon's excellent frictional properties include elevator gibs and sliding parts for storm windows.

Another of nylon's properties, its impact resistance, is particularly valuable for automobile and refrigerator door-closing mechanisms, many housings, cams, and aerosol bottles. Two recent developments are expected to promote this latter market even further. One is the availability of resins designed for extrusion and blow molding and the second is the development of spin-sealing techniques. This technique makes it possible to injection mold a bottle in two halves and economically join them together by a spinning operation.

The strength and stiffness of nylon are required in almost all of its uses. Its retention of these properties at elevated temperatures gives it wide acceptance for coil forms. These have been produced in tremendous quantities—offering economies due to mass production and injection molding techniques and because breakage during winding is minimized. In mixer valves for automatic washing machines, its mechanical properties make it the choice of a large majority of appliance manufacturers.

Nylon's electrical properties are adequate for many other electrical applications where its mechanical properties are of prime importance. These include switch housings, grommets, cable clamps and other fastening devices, insulated connectors, and numerous other molded parts in this category.

Nylon's chemical resistance is a determining factor in many applications. For example, marine equipment, aerosol valve' parts, and moldings exposed to oil well brines must resist electrolytic corrosion. An outstanding new advance is the naval stuffing tube, which is not only lighter and less expensive to produce than the conventional fittings, but also has excellent resistance to salt water corrosion.

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[4] This section based on information supplied by Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc.

Where long-term exposure to elevated temperatures (250° F.) is required, various heat-stabilized resins are available. Useful examples are electronic components and fastening devices for the aircraft industry. Other resins for special purposes include the black weather-resistant nylons. These are suggested for use in agricultural machinery, sporting goods, electrical equipment, and for other applications where outdoor exposure is involved.

Extrusion applications for nylon are expected to account for an increasing share of the total business. Resins of viscosity suitable for molding may be used for simple extrusion operations where retention of shape is not critical. Here the low viscosity of many nylons above their melting points is not a handicap. However, where retention of shape after leaving an extruder die is impor-

TABLE I: The nylons—raw materials, trade names, properties

Chemical basis of nylon	*Common designation*	*Suppliers and trade names*	*Comments on properties*
Hexamethylene-diamine-adipic acid	nylon-6/6	E. I. du Pont de Nemours and Co., Inc.—Zytel 42, 101, 101-2315, 103, 105, 109 and FE-2281	Zytel 42 is an extrusion-grade material with higher melt viscosity; 101 is general-purpose material; 101-2315 same with improved moldability; 105 has added weather resistance, 103 heat-resistance; 109 meets broader range of molding and end-use requirements; FE-2281 has improved hot-water resistance.
Hexamethylene-diamine-sebacic acid	nylon-6/10	E. I. du Pont de Nemours and Co., Inc.—Zytel 31 and 33	More moisture-resistant than the above, more flexible, easier to work, lower in melting point, and less stiff. Zytel 33 is heat-stabilized Zytel 31.
Alkoxy-substituted nylon, hexamethylene-adipic acid		Belding-Corticelli Industries—B.C.I. Nylon	Solution and molding grade resins are available within the 800 series. Flexible thermoset or thermoplastic coatings are applied from alcohol/water solutions. Thermosetting is effected with an acid catalyst and a time/temperature cure.
Not disclosed, possibly a copolymer		E. I. du Pont de Nemours and Co., Inc.—Zytel 63 and 69	Soluble in methanol and ethanol, but cannot be made insoluble. Used chiefly for textile treating.
Not disclosed, made specifically for the Army		E. I. du Pont de Nemours and Co., Inc.—Zytel 3606	Made only to Army specifications for infantry wire jacket.
Polycaprolactam	nylon-6	Plastics and Coal Chemicals Div., Allied Chemical Corp.—Plaskon Nylon 8200 and 8201 E. I. du Pont de Nemours and Co., Inc.—Zytel 211 Spencer Chemical Co.—Spencer Nylon 401, 402, 404, 600, 601, 602, 603, 604, 605, 606, and 607 Foster Grant Co., Inc.—Fosta-Nylon 61A, 61B, 62A-SK, 64A, BK-25T, BK-31G, BK-312, BK-40F, BK-40T, BK-40R Alfred C. Toepfer, Inc.—Grilon American Enka Corp.—Nylenka Catalin Corp.—Catalin Firestone Plastics Co. — Firestone nylon 200, 210	Controllable crystalline structure, permitting orientation for film. Fairly high molten viscosity. Wider plasticizing range for molding larger pieces.
Polymer based on castor oil derivative, 11-amino andecanoic acid	nylon-11	Belding-Corticelli Industries—BCI 1100	Easily plasticized. Low specific gravity. Fairly low melt point but high decomposition point. Very fluid. May be graphited for friction applications. High moisture resistance.

tant, as for blown bottles and any but the most simple shape extrusions, new high-viscosity resins are now beginning to assume a more prominent place in the industry.

The use of nylon as a jacket for wire and cable is well-established. In some cases, such as magnet wire and geophysical cable, it may be used as a primary insulant, but because of its resistance to temperature change, abrasion, grease and oil, it is more common as a jacketing over polyethylene, rubber, or vinyl compounds. Aircraft and other types of hookup wire, tree wire, and electric blanket wire are common examples. The softer grades of nylon are also used for control cable jackets, as in tiller cable for small boats and for various roll-up devices.

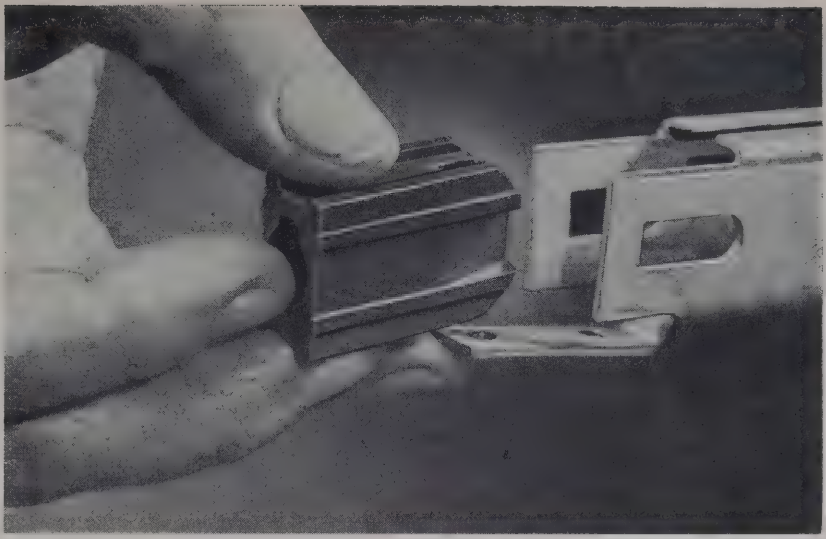
For outdoor applications, weather-resistant grades of extrusion resins have recently become available. These permit construction of highly abrasion-resistant wires with outdoor life comparable to the best materials.

The properties of nylon make it ideally suited for many tubing applications. Its strength, fatigue resistance, and chemical inertness, particularly to hydrocarbons, make it attractive for automotive and other lubrication systems, for fuel lines, air suspension systems, and many other applications. Its lightness and ease of assembly have made possible important economies in a great many installations.

Still other markets exist in films and laminates. Here the high abrasion resistance, high-temperature properties, and chemical resistance are particularly valuable. Grease and oil packages, sterilizable packages, and heavy-duty laminated constructions are examples.

A major potential market exists in the field of aerosol bottles. Here, strength, toughness, and impermeability contribute to the design of attractive bottles of almost unlimited color possibilities, with the added feature of protection against the possible losses and dangers from breakage.

Less rigid and soluble types of nylon find many specialty uses. As moldings, they are useful where extremely high impact strength is required. Examples include soft-faced hammers and bowling pin bases. In the hammer application, prior to the selection of nylon, the manufacturer tested a wide range of materials by striking each one 140 times a minute with a sharp-pointed object giving a 50 ft.-lb. blow. Nylon lasted over 150 hr.—or approximately 1,260,000 blows—2½ times as long as the next best material. In addition, nylon offered several other advantages.



SLIDE used in lock-step oven door molded of molybdenum-disulfide filled nylon meets critical specifications for heat and abrasion resistance, rigidity, and dimensional stability. (Photo, Polymer Products, Inc.)

Applied as solutions or dispersions, the nylons form impermeable linings for aircraft fuel cells, and are widely used as soft, abrasion-resistant finishes.

Nylon is still somewhat underrated in its ability to outwear metals and other materials in general mechanical applications. Up to now, it has been more generally accepted for parts such as bearings, washers, gears, etc., but is now beginning to find increasing use in larger shapes for rollers, wheels, wear plates, slides, dies, mountings, panels, and other wear parts. The unique combination of properties for these applications includes its toughness, resilience, abrasion and wear resistance, low surface friction, nonabrasive surface, and sound-deadening characteristics. Shapes with increasing utility for such applications include nylon tubular bar up to 15 in. outside diameter, plates up to 1½ in. thick, disks up to 7 in. thick and 17 in. outside diameter, and rods up to 8 in. in diameter.

References

Consult the Subject Index for additional information concerning nylon resins. For specific information on injection molding, see p. 594, extrusion, p. 656. See also the Adhesives, Coatings, Films, Laminates, and Plastics Properties Charts. For sources of resins, see Directory Index, p. 1078.

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Phenolics*

The chemistry of phenolics concerns the manner in which various phenols and aldehydes combine to form useful products. The more important of these are initially soluble, liquid, or fusible solid resins which can further react, or thermoset, into rigid, insoluble, infusible structures.

Phenol is reactive toward formaldehyde at three points: namely, the two ortho positions and the para position. When combined with formaldehyde and cured via one of several reaction routes, the resultant product consists of a large network of phenolic nuclei linked together by methylene groups. The formation of a completely cross-linked structure (a portion shown in Fig. 1, below) requires three molecules of formaldehyde for each two of phenol. With less formaldehyde, the cured structure cannot be completely cross-linked and will be less resistant to softening at elevated temperatures.

Replacement of part of the phenol with a phenolic compound having one of its reactive positions blocked, such as ortho cresol, para cresol, or para tertiary butyl phenol, is another means of reducing cross-linking and a means of slowing the rate of cure. When used alone, these phenols produce resins that cannot be cured and their usefulness depends upon other properties. (e.g., para tertiary butyl phenol resins impart good weathering to paints and varnishes.)

While formaldehyde is by far the most important, other aldehydes, such as furfural and acetaldehyde (as paraldehyde), may be employed to get such special properties as a longer flow period.

Base catalyzed reactions

In the presence of basic catalysts, such as sodium hydroxide, calcium hydroxide, or tertiary amines, phenol and formaldehyde form a mixture of addition products called methylol phenols or phenol alcohols. Normally, more than one mol of formaldehyde per mol of phenol is employed and the mixture consists of all of the possible ortho and para mono, di, and trimethylol phenols. These, along with some unreacted phenol and formaldehyde, are the constituents of so-called "water-soluble" liquid phenolic resins.

Condensation

Heating the methylol phenols causes one or more of several condensation reactions to take place. The most important of these is that by which a methylol group is converted to a methylene link between phenols as illustrated by Fig. 2, p. 129.

As the condensation progresses and more and more of the methylol groups are converted to methylene links, the resins become viscous liquids or brittle solids that have lost their water solubility but are still soluble in alcohols and ketones. At this stage the products may be referred to as "resol" or "one-step" resins. Finally, if sufficient formaldehyde is employed in the initial reaction and if all of the methylol groups originally formed are converted to methylene links, the rigid, insoluble, infusible network of Fig. 1 will be formed.

Another condensation reaction that may occur is that by which a methylol group splits off as formaldehyde and a methylene link is formed in the vacated position (Fig. 3, p. 130).

Thus, the blocking of a reactive position with a methylol group does not prevent curing as would an alkyl group in the same position. If reactive positions are available, the newly split-off formaldehyde quickly forms a new methylol group.

Still another type of condensation is shown in Fig. 4, p. 130, where two methylol groups combine to produce a dibenzyl ether bridge. This reaction is favored by neutral or slightly acid conditions and is most likely to occur with the methylols of para substituted phenols. Upon further heating, particularly in the presence of phenols with available reactive positions, dibenzyl ether bridges are also converted to methylene links.

Substituted phenol resins containing methylol and dibenzyl ether groups are useful for their ability to mix and react with drying oils to make fast drying varnishes.

Acid catalyzed reaction

The reaction of formaldehyde with phenol in the presence of acid catalysts may form methylol phenols as intermediate products but, if formed, they are immediately converted to methylene links so that the important overall reaction is one of condensation. Of necessity, such reactions are carried out with less than one mol of formaldehyde per mol of phenol. The products, called novolacs, are friable, fusible,

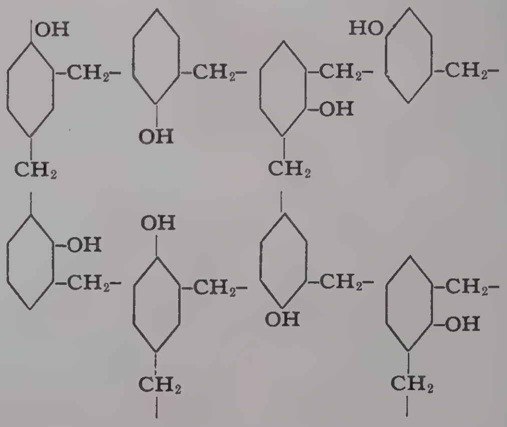

FIG. 1: Portion of crossed-linked structure of cured phenolic resin

thermoplastic, and soluble in alcohols and ketones.

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* Revised and updated by the Technical Staff, Plastics Laboratory, Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y.
References and Recent Developments were prepared by the editors.

Two-step resins

In order to cure, a novolac must be provided with an additional source of formaldehyde or methylene links. Hexamethylenetetramine, the reaction product of formaldehyde and ammonia, is commonly used for this purpose. A mixture of a novolac and hexamethylenetetramine is called a "two-step" phenolic resin. In the curing process, the "hexa" decomposes to provide the necessary methylene links and ammonia is given off. The resultant thermoset material has essentially the same structure as shown in Fig. 1, p. 128.

Intermediate reaction

Best evidence indicates that the intermediate reaction products of a novolac and "hexa" contain di (and tri) benzylamine groups as typified in Fig. 5, p. 131. While reactive phenol positions are available, the benzylamine bridges will decompose upon heating and form the usual methylene links.

The use of ammonia or ammonium hydroxide as a catalyst for the phenol-formaldehyde reaction produces "one-step" type resins that may contain both methylol and di or tri benzylamine groups as reactive intermediate structures. These are readily converted to methylene links as already described.

Phenol reactivity

The reactivity of the ortho and para positions of phenolic compounds toward formaldehyde is affected by the pH of the reaction media and by the presence of substituent groupings on the phenyl ring. For example, novolacs in which ortho-to-ortho methylene links predominate are obtained by carrying out the reaction at a pH of 4 to 5. These novolacs react faster with "hexa" than those made by ordinary acid catalysis. In a somewhat different manner, high pH becomes especially important to base catalyzed reactions when the number of methylols to be formed on a given phenolic compound approaches its total number of reactive positions.

The effect of substituent groupings is perhaps best exemplified by meta cresol, resorcinol, and 2,6 dimethylol phenol, each of which is at least several times more reactive than phenol toward formaldehyde. Resorcinol and paraformaldehyde react without catalyst, the aldehyde being converted to the methylene type linkage.

Alkylation

In the presence of Friedel-Crafts type catalysts, alkylation of a phenol at the ortho and para place easily. The list of alkylating agents includes isobutylene, cyclopentadiene, drying oils, and many terpenes. In general, alkylation softens and slows the cure of phenolic resins but at the same time it improves their compatibility with such materials as drying oils and rubbers.

Molding compounds

Phenolic molding compounds are produced in granular, nodular, or macerated form. These compounds are made by mixing phenolic resins with lubricants, fillers, dyes, and plasticizers. The granular form is prepared by processing the ingredients on heated rolls, cooling the resultant sheet, and grinding to the desired granulation. The nodular type is prepared by an extrusion process which yields short, rod-shaped particles. The macerated form is obtained by mixing phenolic resin and macerated cloth in a sigma blade or similar mixer.

Phenolic compounds are usually

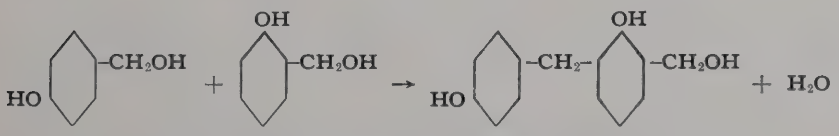

FIG. 2: Condensation of methylol phenols

pments...Recent Developments...Recen

Trimethylolphenol (*BRLA-1030,* Union Carbide Plastics Co.), a new phenolic monomer, presents significant advantages over previous water-soluble phenolic resins that are not monomeric . . . has high methylol content that promotes condensation with carbohydrates and amines . . . practically unlimited dilutability even when strongly acidified . . . better aging properties and low viscosity when cured.

Laminated parts for missiles and rockets, produced with a new phenolic resin (*Plyophen 5900,* Reichhold Chemicals, Inc.), exhibit high strengths at elevated temperatures (4500° F. for brief periods, 500° F. for 100 hr. and longer) . . . low moisture absorption . . . good insulation properties . . . good resistance to organic solvents, weak inorganic acids, hydraulic aircraft oil, de-icing fluids, and hot gas erosion, when reinforced with glass or asbestos.

Two new phenolic-sisal formulations (*RV-825* and *RX-831,* Rogers Corp.) are two-step molding compounds . . . can be preformed and molded on conventional equipment . . . used in electrical and motor housings, outlet boxes, and the like.

Heat-reactive phenolic resin (*SP-126,* Schenectady Varnish Co., Inc.) makes possible production of solvent-type neoprene adhesives with high heat resistance . . . is fast air-drying . . . has good cohesive as well as adhesive properties for glass, steel, and nonporous surfaces. Where high heat resistance is not required, a lower cost companion resin (*SP-560*) is used.

identified in accordance with properties of the finished molded part: general-purpose, impact-resistant, heat-resistant, electrical, and special-purpose. For a discussion of the fillers used to give these properties, see "Fillers for Molding Compounds," p. 436.

Fully cured phenolic molding compounds are hard, rigid, durable, and relatively inert. Most grades are attacked by strong caustic solutions. Since sunlight causes phenolic materials to discolor or darken, only dark colors are produced. Molded phenolic products are slow burning or self-extinguishing.

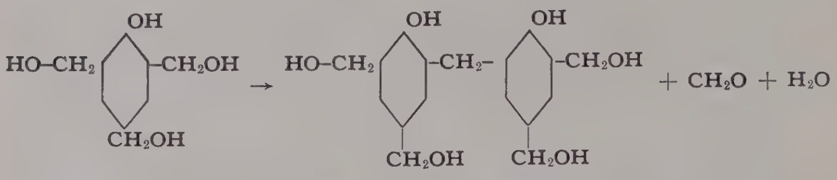

FIG. 3: Condensation accompanied by elimination of formaldehyde

Phenolic compounds can be molded to close tolerances. Three-dimensional tolerance classifications have been established and are listed in the "S.P.I. Engineering Handbook."

Industrial resins

The "industrial resins" are among the later developments of the phenolic resins. Prepared by any appropriate method, they are generally modified to meet specific requirements. Industrial resins include those phenolics employed as bonding resins, impregnating resins, casting resins, and those adapted for innumerable miscellaneous uses.

Foundry industry

The use of phenolic resins for making shell molds for foundry casting offers opportunities for smoother castings, closer tolerances, less machining, and consequent savings in costs. Basically, it consists of producing a comparatively thin shell-like metal casting mold or core by applying a mixture of sand with a phenolic binder (2% to 8% by weight) to a hot metal pattern and curing the layer of material.

Impregnating resins

The term "impregnating resins" designates not only laminating resins but also numerous applications where liquid resins can be used as an impregnant and a bonding agent. Impregnation of different woods and of paper for special-purpose cores and for backing sheets are examples. Paper tubes on which yarns are wound for bleaching and dyeing are often phenolic-impregnated. Modified with lignin, phenolic resins have been used successfully to treat paper as a backing for melamine overlays in laminates. Phenolic-impregnated fabric or paper disks also serve as backings to which abrasive particles are bonded.

The resins can be employed to impregnate wood, thereby increasing strength, decreasing swelling due to moisture, and improving resistance to decay and weathering. The term "impreg" is used to designate wood that has been impregnated with a resin solution and heated to cure the resin. On the other hand, "compreg" is impregnated wood cured under pressure to high density.

A typical high-pressure phenolic laminate is made as follows: A one-step resin is dissolved in alcohol to make a varnish of suitable viscosity to permit saturation of the cloth or paper filler. A web of filler is led into a varnish bath and out through squeeze rolls or over doctor blades. The saturated filler then passes through an oven which removes excess volatile matter and partially polymerizes the resin. A typical treated material, free from tackiness, will contain perhaps 45% resin and 5% to 10% volatile matter.

The treated material is then cut to length and the sheets are placed one on top of the other for pressing between polished steel plates in a hydraulic press with heated platens. Temperatures in the neighborhood of 350° F. and pressures of from 1200 to 2000 p.s.i. are commonly used in high-pressure laminating. In the manufacture of decorative laminates, an opaque sheet printed with the desired design and impregnated with melamine resin is placed on top of the phenolic-treated sheets before pressure is applied.

Resins for structural board

The physical properties of products made from waste wood or particle wood and phenolic resins are dependent upon the type of wood used, the grinding of the wood, the percentage and type of resin used, the moisture content of the wood, and the pressure used. Processing conditions also strongly affect the properties of the finished board. To obtain maximum density and strength, it is important to have a balanced selection of mesh sizes without extremely coarse or extremely fine material included.

There are three different types of production processes: 1) the dry process in which dry powdered resin is used with dry wood waste; 2) the Eastern wet process in which either a liquid resin or varnish is used with dry wood waste; and 3) the Western wet process in which liquid resins are combined with wood waste in a wet slurry. In the dry process and the Eastern wet process both phenolic and urea resins have been used. In the Western wet process only phenolic resin is used.

The dry process of making structural boards out of wood waste plus resin is probably best adapted to small-scale operations. The boards contain from 6% to 15% of the resin and are, therefore, considerably more expensive

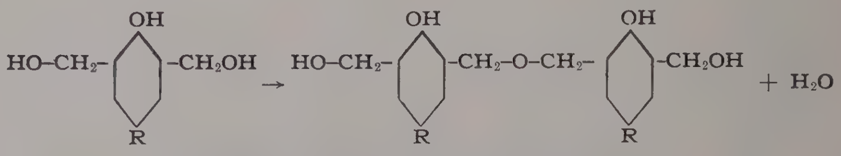

FIG. 4: Condensation to a dibenzyl ether

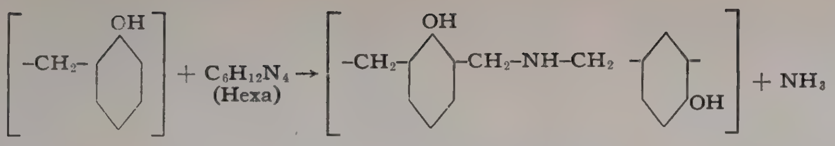

FIG. 5: Formation of a dibenzylamine bridge

—except to maker-users—than nationally distributed structural boards which contain no resin.

The Eastern wet process involves similar economic factors except that, in preparing the wood waste, less care need be taken with particle size. Molded shapes as well as structural board may be made by this process.

The Western wet process requires huge quantities of wood waste and water, high power consumption, and continuous operation. Resin quantities are low, being generally between 2 and 6 percent. A mass production process, it is basically the least expensive from an operating view.

Miscellaneous industrial resins

Resins in this category are numerous and specialized. They are actually impregnants, binders, bonding agents, cements, foamed resins, and other materials, designed for various industrial products.

Specific applications include bonding of abrasive particles to grinding wheels and sandpaper; in clutch facing, brake linings, and other friction materials; in insulation (combined with fibrous rock, slag, or glass, or as phenolic resin foam); bonding magnetic iron powder for use in electrical coils in radio and high frequency applications; cementing glass bulbs of radio tubes and electric lamps to molded or metal bases; bonding and securing brush bristles; etc.

Liquid phenolics, essentially mixtures of phenol alcohols with a relatively small proportion condensed to an advanced stage, can also be cast into tools, trophy bases, rods, tubes, shapes, etc.

Resorcinol-formaldehyde

Resorcinol has a higher rate of reactivity than phenol under some conditions. This is due to the fact that there are two activating OH groups, as opposed to the one activating group in phenol. The order of reactivity of resorcinol with formaldehyde is such that no catalysts are necessary to induce reaction, which will take place under acid or alkaline conditions. By reacting one mol of resorcinol with substantially less than one mol of formaldehyde, resins are obtained which are permanently fusible and soluble in water, ketones, alcohols, esters, and similar organic solvents. These resins can be repeatedly heated with no substantial change in properties. By dissolving in a solvent medium, usually water and alcohol, and adjusting the pH of the solution to approximately 7, an adhesive base is formed which can be set in the presence of a hardening agent, generally formalin or para-formaldehyde. In a similar manner, copolymer phenol-resorcinol-formaldehyde adhesives can be prepared that set at a pH of about 8 and show about the same reactivity as the resorcinol adhesives.

Resorcinol resin adhesives can be used quite generally where phenolics are used. The low-temperature cure is particularly helpful in the fabrication of heavy structures with thick sections where slow heat transfer retards the cure of normal phenolics, or in gluing odd-shaped pieces that cannot be handled well between the flat platens of a hot press. Because of their high affinity for wood, the most important use of these resin adhesives has been in wood gluing, particularly for marine plywoods.

Phenol-furfural

Phenol-furfural resins are capable of complete cure, forming products of high strength and exceptional chemical resistance. Among other notable characteristics of phenol-furfural resins are their extended flow at low molding temperatures and rapid cure at between 375 and 400° F.

Furfural resins as currently used contribute special and useful flow properties to the phenolic resins of commerce. They are primarily used in reaction with phenol to prepare lump resins which in turn are ground and blended with fast-curing phenol-formaldehyde powdered resins in suitable ratios. Another method is to react mixtures of furfural and formaldehyde with phenol. Regardless of how made, the blends are either compounded with fillers in the case of molding compounds, or become resins of commerce employed as bonding or adhesive agents or in varnishes, etc.

References

Consult the Subject Index for additional information concerning phenolic resins. For specific information on compression and transfer molding, see p. 631, laminating, see p. 468, casting, see p. 728. See also the Adhesives, Coatings, Foamed Plastics, Laminates, Low-Pressure Laminating Resins, and Plastics Properties Charts for information on properties and trade designations. For sources of phenolics, see Directory Index, p. 1078.

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Polycarbonate

By R. J. Thompson and K. B. Goldblum*

The polyarylcarbonate polymer, a recently developed thermoplastic resin, is rapidly opening up broad markets because of a unique combination of useful properties. These include: 1) high impact strength (over 12 ft.-lb. per inch of notch); 2) excellent dimensional stability under conditions of widely varying humidity and temperature; 3) superior heat resistance (the 280 to 290° F. heat distortion temperature is complemented by high resistance to thermal oxidative degradation up to 300° F.); and 4) good electrical properties.

This resin (Lexan[1]) is an entirely new composition in the thermoplastic family. The name "polycarbonate" is taken from the carbonate linkage which joins the organic units in the polymer. This is the first commercially useful thermoplastic material which incorporates the carbonate radical as an integral part of the main polymer chain.

Chemistry

Basically the polyarylcarbonates are bisphenol radicals joined together by carbonate linkages to form large molecules. The manufacture can be done by 1) ester exchange or 2) the direct reaction of phosgene with the bisphenol.

Processing

The aromatic polycarbonate resins have been processed by virtually every method and technique used in thermoplastic technology. The densification of the polymer particles after manufacture is done by extrusion and chopping.

For a discussion of injection molding of polycarbonate, see the article on p. 610.

Experimental information on extrusion conditions indicates that temperatures of 450° to 550° F. can be used in the barrel. Water cooling of the screw is not recommended because of the high melt viscosity developed. The feed to the extruder must be as moisture-free as possible; this is even more important in extrusion than in injection molding. The presence of moisture will be indicated by small bubbles in the body of the extruded shape. If the moisture content is high enough, the extruded material will be foamy in appearance. Low stock temperature is indicated by cloudy parts and a somewhat rough surface.

Properties

Low water absorption of molded parts is important because moisture often affects dimensional and chemical stability, as well as mechanical and electrical properties in most thermoplastics. Polycarbonate resin exhibits relatively low water absorption. Exposed to 50% relative humidity at room temperature, polycarbonate resin parts reach equilibrium in about 10 days at 0.15% water content; when immersed in water at room temperature, a maximum of 0.35% is absorbed. In boiling water, the maximum absorption of 0.58% is rapidly attained. Normally, polycarbonate parts will only expand ¾ mil/in. on absorption of 0.35% moisture.

Like other amorphous polymers, polycarbonate resin has no precise melting point. It softens and begins to melt over a range from 420° to 440° F.

Significant in the processing of the resin is its thermal stability. The melt viscosity shows no degradation over periods exceeding the residence times used in normal injection cycles. In fact, the melt viscosity may increase somewhat over the interval. Studies of the effect of the injection pressure on melt viscosity also show that the polycarbonate resin is much less affected by pressure than the normal thermoplastics; that is, the polycarbonates are less non-Newtonian in their rheological behavior than other thermoplastics by a factor of five to ten times.

Many of the useful properties of the bisphenol A polycarbonate resin seem to stem from the relatively high degree of order in the amorphous state, as shown by X-ray diffraction studies. These studies also indicate that in the crystalline state there is a goodly degree of disorder. The high softening temperature and the ability of this material to absorb impact blows may be explained by these findings. This may also explain the fact that the heat distortion point is not very dependent on loading. Polycarbonate resins show approximately the same heat distortion point at 264 p.s.i. as at 66 p.s.i. Since most thermoplastic resins give significant drops at the higher loading, this is an important and useful advantage for polycarbonates.

Polycarbonate resin has good electrical properties which make it suitable for applications where insulation characteristics are needed. Of special interest is the low power factor of 0.0009 at 60 cycles/sec. from room temperature to 100° C.

Applications

The high impact strength of polycarbonate resin suggests its use in applications where toughness is a requisite. Housings for business machines, communication equipment, and electrical apparatus fall in this category. Unlike most other thermoplastics, polycarbonate maintains a high level of impact strength from very low temperatures up to the heat distortion point. This feature is particularly important in many military applications where a part must be serviceable from —60° to +180° F. The resin's colorability, transparency, and self-extinguishing rating recommend it for many uses.

The dimensional stability of polycarbonate moldings under a wide variety of temperature, humidity, and environmental conditions, coupled with impact strength and heat resistance, opens up a variety of potential

(*Continued on page 141*)

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* Chemical Materials Department, General Electric Co., 1 Plastics Avenue, Pittsfield, Mass.

[1] Trademark of General Electric Co.

References were prepared by the editors.

thermosetting molding compounds

fire-retardant resins for reinforced plastics

bonding and coating resins

DUREZ PLASTICS DIVISION
888 Walck Road, North Tonawanda, New York

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thermosetting molding compounds

WHEN TO USE

In general, designers specify a thermosetting molding compound to meet one of the following product requirements or any combination of them:

low cost General-purpose phenolics are the lowest-priced compounds, per pound and per unit of volume. Molding costs per piece are low, and are moving lower with increasing use of automatic molding equipment.

dimensional stability Phenolics and diallyl phthalates exhibit high degrees of resistance to deformation under load (cold flow), and swelling or shrinking due to absorption of moisture. Molded parts exhibit relatively slight change in dimensions with changes in temperature, an advantage in the design of precision devices.

heat resistance Most thermosetting compounds can be safely specified for operation at temperatures above 300°F. Some can go as high as 500°F.

moisture resistance Thermosets stand long exposure to moisture with relatively slight change in strength and other characteristics. Outstanding in this respect are Durez diallyl phthalates.

electrical insulating properties A wide choice of electrical-grade thermosetting compounds permits accurate selection of the desired levels of arc resistance, dielectric strength, insulation resistance, dissipation factor, in combination with heat and moisture resistance and other physicals.

impact strength Compounds filled with cotton flock, cellulose, sisal, or glass fiber provide a range of medium- and high-impact materials suitable for industrial housings, pulleys, automotive transmission parts, oil-pump gears, and other applications of hard usage.

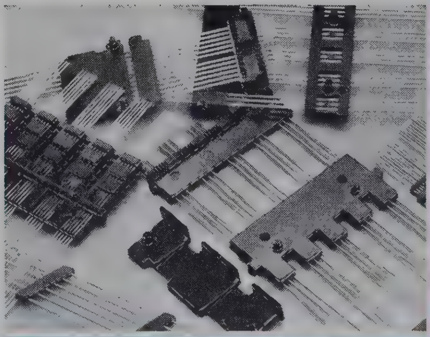
chemical resistance Thermosetting compounds are inert to most common solvents and weak acids. Many available compounds are resistant to food and beverage stains, and are unaffected by skin acids and perspiration.

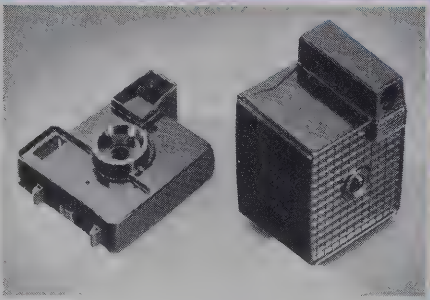
WHERE TO GET MORE FACTS

The plastics molder is familiar with Durez materials, and experienced in matching them to the designer's needs. His services include cost estimating, advice on mold design, and quality control to meet specifications. Whenever possible, call him in early. He can often suggest ways to reduce molding cost or provide savings in assembly.

For information on specific Durez molding materials, write us outlining the requirements. Design data readily available include molding characteristics, properties of compression-molded material, machining and finishing characteristics, and suggestions on piece design.

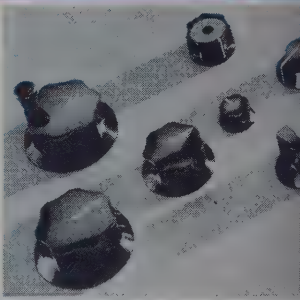
Durez sales engineers and technical service men will gladly consult with you on any problem involving material selection or application. Many compounds are formulated to meet special needs.





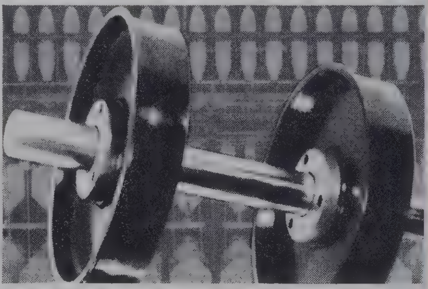
Wire spring relay for telephone systems

Modern camera case

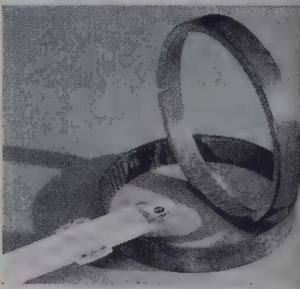


Switch assembly with molded-in holes

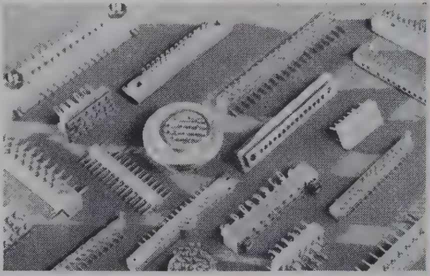
Instrument knobs in a stock design



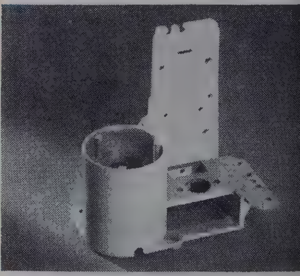
Low-cost textile pulley



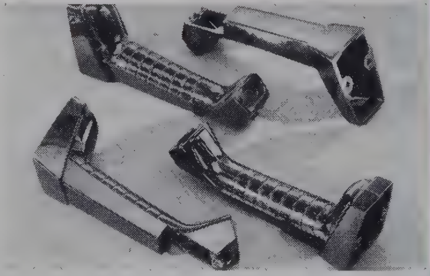
Clutch cone that outwears metal



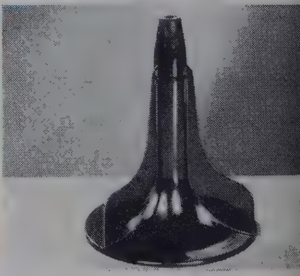
High-precision electronic components



High-voltage throne for television receiver

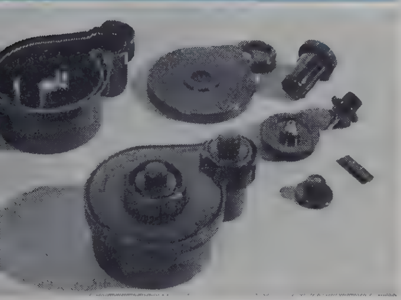


One-piece handle for electric skillet



Detergent-resistant washing-machine agitator

DUREZ molding compounds



Gasket cutter; scales molded in place

Photographic developer tank

general-purpose

By far the greatest quantity of rigid plastic parts are molded of general-purpose phenolics, the lowest-cost compounds. These materials consist of phenol-formaldehyde resins to which has been added wood flour or other filler.

When such a compound is compressed in a hot mold, it becomes plastic and flows, filling the mold cavity. Then it hardens by irreversible chemical reaction. Products so molded are rigid. Once molded, they do not melt, soften, or change shape with further exposure to heat.

Qualities most often considered when selecting a general-purpose phenolic include mechanical strength, dimensional stability in the presence of heat and moisture, corrosion resistance, surface smoothness and gloss, electrical characteristics, and machinability.

Since no material is ideal for every application, some 20 Durez general-purpose compounds are offered. All provide the most looked-for properties in balanced degree. At the same time, the wide variety makes possible close matching of design requirements with a compound that emphasizes any one property, or a specific combination of properties.

piece design can take advantage of the materials' ability to accommodate molded-in metal inserts, contacts, terminals, wires, and inlays to simplify later assembly. Strong threads can be molded in without extra operations. Self-tapping screws may be used in molded-in holes.

Tolerances can be held to ±.002″ on small dimensions, though ±.004″ is more usual.

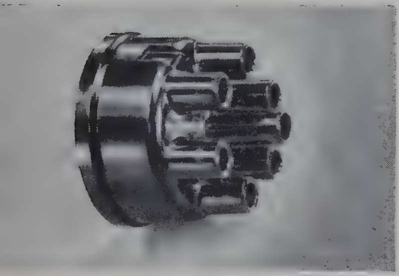
machining Molded pieces can be Wheelabrated, filed, sanded, ground, tapped, and drilled. Milling and turning, while not recommended, is satisfactory with some compounds, depending on type of filler.

finishing Molded pieces can be tumble polished to provide high gloss, or buffed. Phenolics can be marked by branding or machine engraving. Pieces can be painted or vacuum metallized.

Junction box for industrial service

impact

New Durez impact phenolics open the door to many possibilities for better performance in high-strength parts. Izod impact higher than 17 ft.-lb./in. can be achieved. One example is a reverse clutch cone for automatic car transmissions. The part is subjected to severe static and dynamic friction, developed heat, a 5,000-lb. force of an actuating piston, and the chemical effects of transmission oil. It outperforms metal counterparts, weighs less, and costs less to produce.



Automotive distributor cap

electrical and electronic

Light weight, dimensional stability, and excellent insulating properties are obtained with Durez electrical-grade phenolic molding compounds. Some are formulated especially for molding around large metal inserts. Several are designed to meet military specifications. Available also, for highest-quality components, are Durez diallyl phthalate compounds reinforced with orlon or glass fiber. These materials retain high insulation values over extended periods at relative humidities above 90%. They exhibit consistently reproducible arc resistance, and provide virtual freedom from cold flow and creep. They are widely used in rocket and missile components.

Non-bleeding cap for perfume bottle

other types

heat-resistant phenolics, with mineral fillers, withstand high operating temperatures and yet retain a high degree of dimensional stability. Most compounds in this class are designed to take 72-hour heat treatment at 392°F. Some will survive 450°F. for relatively long periods, and higher temperatures for shorter periods, without serious impairment of physical properties or molded appearance. Several types of these compounds are currently available.

non-bleeding Intended primarily for caps and closures, these odorless phenolics are highly resistant to most common organic solvents. Some will stand repeated autoclave sterilization at 275°F.

special-property compounds of several types are offered for applications demanding highest resistance to chemical corrosion or moisture penetration. Also available are phenolics with self-lubricating properties.

For more detailed selection data, see pages 4 and 5

PLASTICS

Selection Guide

MATERIAL		**general-purpose phenolic**							**non-bleeding phenolic**
USES		Pieces requiring balanced properties at lowest cost. Examples: cases, cabinets, housings, tube bases, sockets, switches, other electrical components, control knobs, utensil handles.							Caps and closures, esp. for products containing alcohol.
DESIGN ADVANTAGES		Part design and mold construction are simplest when general-purpose compounds can be used. Special variations developed by Durez enable these materials to do better jobs in specific applications. For example, when noncorrosive properties are needed in electrical applications, Durez 15528 should be specified. Similarly, some general-purpose compounds possess improved machinability, insulation resistance, and resistance to perspiration acids. Custom molders are familiar with their qualifications. If you would like to consult with our technical service or sales engineers, write us regarding the application.							Minimum odor and taste are important here.
PROPERTIES	ASTM test method								
physical									
color		brown	black	black	black	black	black	black	black
specific gravity, avg.	D 792	1.42	1.36	1.40	1.37	1.37	1.38	1.34	1.38
molding shrinkage, in/in, avg.	D 955	0.006	0.006	0.006	0.006	0.005	0.006	0.006	0.006
water absorption, %, max.	D 570	0.7	0.7	0.5	0.6	0.6	0.7	0.7	0.8
distortion under heat, °F, 264 psi, min.	D 648	310	300	300	320	320	270	300	325
mechanical									
impact, Izod, ft-lb/in, min.	D 256	0.28	0.28	0.26	0.31	0.31	0.28	0.28	0.28
flexural strength, psi, min.	D 790	10,000	11,000	11,000	11,000	10,000	9,000	10,000	9,000
tensile strength, psi, min.	D 638	7,000	7,000	7,000	7,000	6,500	6,000	6,000	7,000
compressive strength, psi, min.	D 695	30,000	30,000	30,000	30,000	30,000	25,000	30,000	25,000
modulus of elasticity in tension, psi, avg.	D 638	1.5×10^6	1.2×10^6	1.3×10^6	1.2×10^6	1.0×10^6	1.2×10^6	1.1×10^6	1.4×10^6
hardness, Rockwell, M scale	D 785	115	116	113	113	116	110	112	110
electrical									
dielectric strength, v/mil, min.:	D 149								
short time		320	325	350	350	375	325	375	200
step by step		260	260	275	275	300	250	300	200
volume resistivity, ohm cm, min.	D 257	1×10^{12}	1×10^{12}	5×10^{11}	1×10^{12}	5×10^{11}	1×10^{11}	1×10^{11}	1×10^{12}
dissipation (power) factor, avg.:	D 150								
60 cycle		0.08	0.07	0.2	0.06	0.3	0.05	0.11	
1 kilocycle		0.05	0.04	0.09	0.04	0.1		0.06	
1 megacycle		0.04	0.03	0.045	0.035	0.05	0.04	0.04	0.05
dielectric constant, avg.:	D 150								
60 cycle		6.2	5.8	7.7	5.6	10.0	6.0	6.4	
1 kilocycle		5.6	5.4	6.9	5.2	6.0		5.6	
1 megacycle		4.8	4.7	5.0	4.6	5.0	5.0	4.8	7.2
arc resistance, sec., avg.	D 495								
DUREZ NUMBER		740	791	792	11540	12995	15528	19206	3949

This table presents values of representative Durez products, based on tests of compression-molded specimens. Many other materials are available. For complete information, consult your molder or write us direct.

DUREZ molding compounds

to Representative Materials

impact phenolic			electrical phenolic			diallyl phthalate		heat-resistant phenolic		special-purpose phenolic	
Pieces subject to comparatively rough handling or heavy wear. Examples: automotive transmission parts, oil-pump gears, telephone parts, bushings, caster wheels, tool parts, pulleys, instrument cases, machine housings.			Pieces subject to electrical stress. Examples: automotive ignition parts, resistor casings, coil forms, tube bases, distributor caps, commutator assemblies, electronic components of many types.					Pieces that must withstand higher-than-usual service temperatures. Examples: electric-iron and utensil handles, toaster and coffee-maker parts.		Pieces in contact with water and detergents, or requiring exceptional corrosion resistance; self-lubricating parts. Examples: washing-machine agitators, pumps, valves; casters, rollers, guides.	
When extra resistance to shock is needed, impact materials should be considered. A wide range of these rugged materials, with impacts from 0.3 to 17 ft-lb/in Izod, enables the designer to avoid expensive over-engineering.			Properties needed in automotive ignition systems differ, of course, from those needed in heavy-duty circuit breaker parts. We will gladly help you evaluate the often subtle advantages of one electrical-grade material over another for a specific problem. As one example, Durez 16694 diallyl phthalate meets situations where absolute reliability of the insulation resistance, in hot-or-cold and wet-or-dry conditions, is a must.					Most phenolics perform well at temperatures up to 300°F. These standard materials are designed for service starting at 300°F and going as high as 500°F.		Resistance to soaps, detergents, chemicals, and unusual moisture conditions are built into these materials. Durez 13856 is formulated to meet wet-on-one-side, dry-on-the-other specifications.	
black	natural	black	black	natural	black	green	green	black	black	black	black
1.37	1.83	1.42	1.36	1.75	1.66	1.31	1.65	1.57	1.64	1.38	1.41
0.006	0.0009*	0.006	0.006	0.003	0.004	0.009	0.006	0.004	0.004	0.006	0.006
0.7	0.8	0.9	0.7	0.06	0.4	0.2	0.2	0.4	0.2	0.4	1.0
300	600	270	275	285	300	240	300	300	330	320	300
0.37	15.0	1.20	0.26	0.30	0.36	0.55	0.28	0.26	0.28	0.20	0.48
11,000	20,000	8,500	10,000	9,500	9,500	10,500	8,500	9,500	8,500	8,000	9,500
7,000	7,000	5,500	6,500	5,500	5,000	4,500	4,000	6,500	5,500	4,500	6,500
30,000	16,500	25,000	30,000	25,000	24,000	20,000	21,000	28,000	22,000	26,000	27,000
1.3 x 10^6	3 x 10^6	1.3 x 10^6	1.3 x 10^6	2.5 x 10^6	1.7 x 10^6	0.6 x 10^6		1.5 x 10^6	1.5 x 10^6	0.9 x 10^6	1.2 x 10^6
113	90	105	115	105	107	108	100	112	110	112	107
350 275	400 300	225 200	400 325	375 300	400 300	400 350	450 350	350 270	300 250	230 200	175 175
1 x 10^{12}	1 x 10^{12}	1 x 10^{12}	1 x 10^{13}	1 x 10^{13}	1 x 10^{12}	1 x 10^{16}	1 x 10^{14}	1 x 10^{12}		1 x 10^{14}	1 x 10^{11}
0.15 0.06 0.04	0.05 0.02 0.02	0.17 0.10 0.05	0.03 0.25 0.03	0.04 0.025 0.013	0.14 0.14 0.05	0.026 0.020 0.016	0.06 0.05 0.03	0.09 0.06 0.35	0.07	0.16 0.10 0.045	0.26 0.12 0.05
6.8 5.7 4.9	6.8 6.7 6.0	8.5 7.0 5.2	5.4 5.1 4.7	5.2 4.9 4.6	10.0 7.5 5.0	3.8 3.7 3.6	5.2 4.8 4.2	7.0 6.1 5.0	5.5	8.7 7.0 5.5	11.0 7.8 5.9
					180	85	140				
1544	16771	18683	2271	16274	18001	16694	17877	1308	19089	75	13856

* expansion

The information presented herein, while not a guarantee, is to the best of our knowledge true and accurate. No warranty or guarantee is made regarding preformance or stability of any product, since the manner of use and conditions of storage and handling are beyond our control. No suggestion for product use shall be construed as a recommendation for its use in infringement of any existing patents or to violate any federal, state, or local laws.

PLASTICS

when to use HETRON® resins

Hetron polyester resins produce strong, fire-retardant laminates and molded shapes of virtually any size.

The resins are designed for use with a reinforcement of fibrous glass mat, glass cloth, chopped roving, or textile fabric. Rigid, semi-rigid, or flexible laminates can be made, depending on the resin selected. Further choice of rigid and semi-rigid resins permits emphasis on heat resistance, impact, and finishing qualities.

Among the design considerations leading to selection of a Hetron resin are the following:

structural strength required over a large surface area; high strength-to-weight ratio.

fire retardance for applications where conventional laminates constitute a hazard, or where building codes or insurance regulations require a slow-burning or self-extinguishing material.

corrosion resistance, as for chemical ductwork.

arc resistance and other insulating qualities.

smooth, hard surface with good impact strength and finishing properties.

light transmission, for applications such as industrial glazing or interior decoration.

integral color.

applications Current uses for Hetron laminates include automotive fenders and other body parts; commercial aircraft luggage pods, air-conditioning ducts, cockpit glare shields, and light-diffuser panels; industrial glazing and roofing; corrosion-resistant blowers, ducts, and fume hoods; bus seats; fire-retardant pleasure craft; corrosion-resistant utility-boat hulls; outboard-motor housings; business-machine housings; insulation for heavy-duty metal-clad switchgear; perforated wiring ducts for electrical control panels.

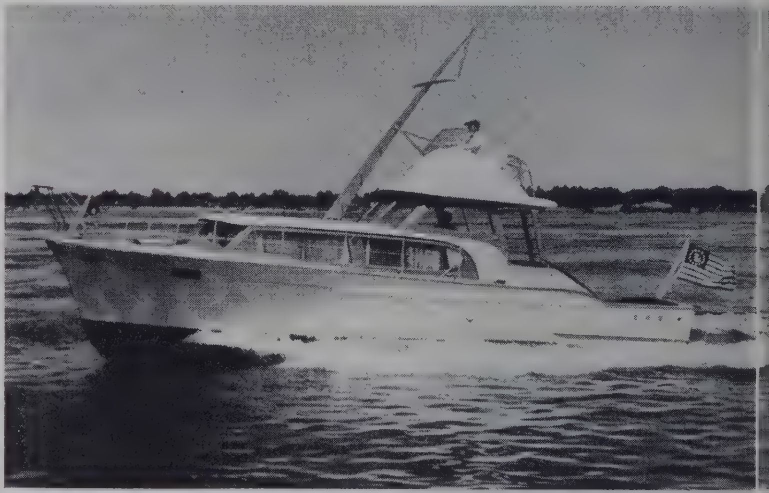
Military uses include aircraft wing tips, tail fins, window frames, air ducts, battery trays, radomes, and antenna covers; 40-foot landing craft hulls; 55-foot radomes for perimeter defense; portable hangars for jet aircraft.

paper-based laminates Laminates prepared from phenolic pre-impregnated kraft paper and *Hetron 92* have water absorption values ranging from 0.3% to 1.0% on a ⅛-inch specimen, depending on resin content and method of preparation. Advantages of these laminates over phenolic NEMA XXX grade include excellent fire retardance, shorter impregnating and curing time, and use of low-pressure forming equipment (100-400 psi).

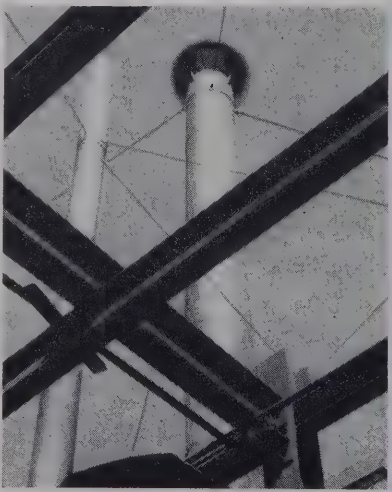
for more information, request the complete data file on Hetron resins. We shall be glad to supply names of leading fabricators who can produce sheets, panels and molded shapes made with Hetron. Durez technical service men are ready to work with you or with your fabricator on any potential application.

BUS SEATS of tough Hetron resist vandalism, and far outlast upholstered seats.

SAFE DAYLIGHTING PANELS made with Hetron carry U/L and Factory Mutual label



FISHING BRIDGE on Richardson custom sport cruiser is sturdy, fire-retardant, and weighs only 100 pounds.



DUCTWORK, fume hoods, and blowers of Hetron outwear other materials in corrosive service.

FIRE-RETARDANT, arc-resistant Hetron laminates are offered in many shapes by fabricators.

HETRON fire-retardant resins for reinforced plastic laminates and molded shapes

properties of HETRON laminates

physical Hetron laminates are self-extinguishing. Flame retardance is chemically inherent in the resin, obtained without additives and consequently without loss of mechanical strength.

Typical panels test within a range of 20 for highly filled panels to 75 for translucent panels in flame-spread rating by ASTM E84-50T (Tunnel Test), as compared with ratings of 100 for red oak and over 400 for conventional unfilled polyester panels.

Castings cured without filler exhibit heat distortion points as high as 300°F by ASTM D648-45T.

mechanical Typical ⅛-inch rigid laminates containing 40% resin and 60% glass cloth exhibit flexural strength of 68,700 psi at 73°F, and 55,100 psi at 160°F.

Water absorption is very low. After a two-hour boil the same laminates have flexural strength of 59,800 psi at 73°F. Flexural modulus of 3.1 x 10^6 psi at 73°F is equally well retained after a two-hour boil. Compressive strength is 35,000 psi and tensile strength 40,000 psi at 73°F.

electrical Good electricals, plus flame retardance, make Hetron a preferred choice for glass-reinforced sheet insulation in heavy-duty circuit breakers and other apparatus. Other properties include very low loss factor over a wide range of frequencies; dielectric constants generally lower than with resins of this type; relatively slight change in properties with exposure to high humidity.

chemical Laminates withstand long-time immersion in water, dilute hydrochloric acid, 60% sulfuric acid, and kerosene over a range of temperatures with little or no weight change.

typical properties of HETRON RESINS as supplied

type and no.	characteristics	suggested applications	viscosity, Gardner, at 73°F, poises	sp. gr. at 73°F.	SPI gel time, min.	flame retardance*	heat distortion pt*., ASTM D648
rigid types: 92	Very high fire retardance. High heat distortion point. Good resistance to water absorption. Low viscosity. Low shrinkage.	Machine housings, electrical insulating, board and parts, radomes, aircraft parts, structural panels, chemically resistant tanks and ductwork.	13–18	1.34	5–6.5	SELF-EXT.	220°F
72	High chemical resistance. Excellent heat resistance. Hish heat distortion point.	Chemical tanks and ductwork; other high-temperature applications.	13–18	1.23	4.5–6.5	SELF-EXT.	300°F
93LS	Light-stabilized. Excellent weathering characteristics. Same fire-retardant qualities as Hetron 92.	Skylights; explosion windows; industrial and commercial glazing where codes require a flame-resistant material.	5–6	1.30	5–6.5	SELF-EXT.	180°F
103	High-viscosity non-volatile liquid resin. High heat distortion point; low shrinkage on cure. Laminates incorporate excellent heat resistance and high-temperature strength.	High-temperature applications, such as prepregs for aircraft or structural panels.	over 1,000	1.31	5–6.5	SELF-EXT.	300°F
semi-rigid types: 32A	Excellent tensile strength and tensile elongation. Excellent heat resistance. Laminates have a good resistance to impact cracking.	Automotive and truck body panels and structural members; boat hulls and machine housings.	13–18	1.31	5–6.5	SELF-EXT.	170°F
31	Exceptional resistance to cracking on rapid cure. Very high impact strength, retained at temperatures as low as −20°F.	Gel coats for hand layup parts, chemically resistant piping, boat covering kits.	9–11	1.28	5–6.5	SELF-EXT.	120°F
base resins: 17	Solid, unsaturated linear alkyd with no monomer added.	Prepregs for high-temperature strength and chemical resistance.	solid			SELF-EXT.	
19	Virtually the same as Hetron 17.	Prepregs with high-temperature strength and fire resistance.	solid			SELF-EXT.	

* For castings cured without filler.

typical glass laminate properties

mechanical

tensile strength, psi	21,700-40,400
compressive strength, psi	23,600-37,500
flexural strength, psi	37,200-55,100
flexural modulus, psi x 10^6	1.9-3.0
impact, Izod, ft-lb/in	15-30
Hardness, Barcol	45-55
burning rate, in/min	0.12
flammability	SELF-EXT.

electrical

dielectric strength, v/mil, s/t	365–390
s/s	340–398
volume resistivity, ohm cm	1.9 x 10^{16}
dissipation factor, 60 c	0.003-0.007
1 kc	0.004-0.007
1 mc	0.009 0.013
dielectric constant, 60 c	2.95-3.37
1 kc	2.93-3.35
1 mc	2.93-3.31
arc resistance, sec	110

**WE DO NOT PRODUCE LAMINATES, but will gladly furnish names of leading commercial fabricators who can supply laminates made with Hetron. Values shown are representative, based on tests of laminates of various thicknesses and glass/resin ratios.

PLASTICS bonding and coating resins

bonding resins

Many products employ Durez thermosetting phenolic resins as bonding or impregnating agents. During processing, the resins harden permanently at temperatures of 250-350°F. They impart lasting mechanical strength, water resistance, electrical insulation characteristics, frictional stability, resistance to solvents, mild acids and alkalies.

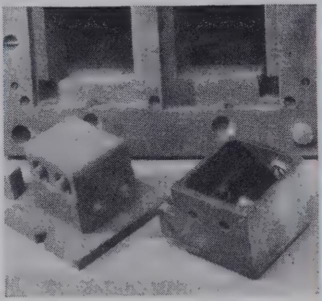
A wide choice of resins is available in the form of lumps, powders, liquids, solutions, and emulsions. In addition, standard resins may be modified to develop properties needed for new applications. For further information, send for the 12-page bulletin, "Durez Industrial Resins", which describes the use of these resins in specific products.

coating resins

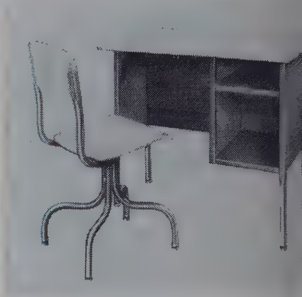
Many coatings and finishes are improved by formulation with Durez phenolic resins. The resins are used in wax emulsions and floor dressings to improve water resistance, wear, slip resistance, and gloss.

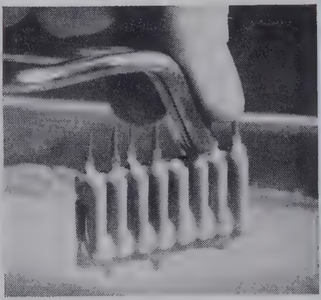
Many varnishes and enamels are made with Durez resins. In brushing and spraying finishes, the resins add durability and resistance to acids, alkalies, and water.

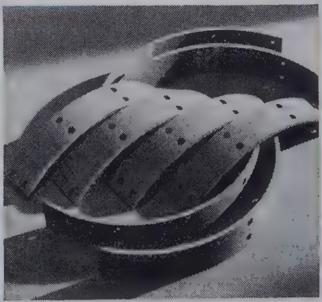
Durez resins also impart desirable properties to heat-set and gel-type printing inks and overgloss varnishes used in printing.


shell molds and shell cores for metal castings provide excellent pattern detail and high strength when bonded with Durez foundry resins.

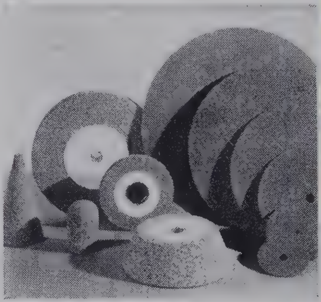
rubber compounds are improved with Durez resins. Small amonnts increase strength and hardness. Neoprene and nitrile rubber cements containing them have both adhesion and heat resistance.


wood flour or coarse ground wood is mixed with Durez resins to form dense, strong boards, sheets, and molded shapes that resist warpage.

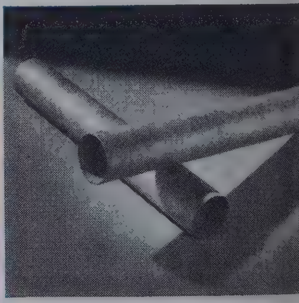

electronic components are insulated with strong heat- and moisture-resistant coatings made with a Durez phenolic resin compound.


brake linings, brake blocks, clutch facings bonded with Durez resins resist heat, water, grease, have uniform coefficient of friction.

quick, low-cost casting of short-run parts is possible with Durez casting resin. No pressure is used; only a mild bake is required.


abrasive bonding Grinding wheels, abrasive discs, and papers bonded with Durez resins combine strength and efficiency.

corrosion-resistant mortars Special mortars that must withstand both acids and alkalis employ Durez furfuryl-alcohol resins.


laminates Durable sheets, tubes, formed shapes are made by impregnating paper or fabric with Durez resin solutions, then pressing.

where to go for information samples technical service

main office	phone	Twx
North Tonawanda, N. Y.: 888 Walck Road	LUdlow 1860	TON 565
district sales offices		
Chicago 2: 1 North LaSalle Street	FRanklin 2-8757	CG 749
Detroit 2: 503 Stephenson Building	TRinity 3-3700	DE 1175
Kenton, O.: P.O. Box 168	KEnton 4076	KENTON 0-89
Los Angeles 5: 3325 Wilshire Boulevard	DUnkirk 5-4404	LA 323
New York 17: 60 E. 42nd Street	MUrray Hill 2-2500	NY 1-21
Philadelphia 3: 6 Penn Center Plaza	LOcust 7-2180	PH 757

DUREZ PLASTICS DIVISION
888 Walck Road, North Tonawanda, New York
HOOKER CHEMICAL CORPORATION
HOOKER CHEMICALS PLASTICS

Form No. D400—5-59

Printed in U.S.A.

applications. Electrical connectors, cams, gears, coil forms, and terminal blocks are among the items which benefit from the properties of polycarbonate resin. The trend toward smaller electrical equipment usually means increased operating temperatures. The good electrical properties and high heat resistance of polycarbonate resin make it an attractive material for design of such parts.

There is a growing need for plastics with higher heat resistance; parts for electronic equipment, appliances, and heating apparatus must meet increasing temperature requirements. The combination of transparency and high heat distortion point suggests uses for polycarbonate resin in lenses and instrument windows where environmental or illumination heat call for high temperature stability. Polycarbonates have already been adopted for use in aircraft instruments and lenses, oil sight gages, and transparent appliance parts. Superior heat resistance makes it suitable for these uses.

An interesting application area for polycarbonate resin is in fabricating fasteners of various types. Polycarbonates have high creep resistance which is essentially maintained at elevated temperatures. Such uses include grommets, rivets, eyelets, bolts, nails, staples, and nuts. The ability of polycarbonate parts to be cold-headed and cold-formed has developed considerable interest in rivet applications. Also, solutions of polycarbonate resin show promise as bonding or cementing agents in certain uses; the resin maintains its bond strength over a wide temperature range.

The polycarbonate molding compound described above is only one member of the polycarbonate family. As variations in properties are needed, other polycarbonate resins will probably be introduced.

Properties of molded polycarbonate

Physical properties		*ASTM test*
Specific gravity	1.20	D 792
Refractive index at 25° C.	1.586	—
Rockwell hardness	M70, R118	D 785
Abrasion resistance, Taber Abraser with CS-17 wheel, 1000 g. load	24 mg./1000 cycles	D 1044
Impact strength, notched Izod	12-16 ft.-lb./in. of notch	D 256
Tensile-impact (Bragaw, MODERN PLASTICS *33*, 199; June 1956)	600-900 ft.-lb./cu.in.	—
Tensile yield strength	8000-9000 p.s.i.	D 638
Tensile ultimate strength	9000-10,500 p.s.i.	D 638
Tensile modulus	320,000 p.s.i.	D 638
Elongation	60-100%	D 638
Poisson's ratio	0.38	—
Compressive strength	11,000 p.s.i.	D 695
Compressive modulus	241,000 p.s.i.	D 695
Flexural strength	11,000-13,000 p.s.i.	D 790
Flexural modulus	375,000 p.s.i.	D 790
Modulus of rigidity	116,000 p.s.i.	—
Shear ultimate strength	9,200 p.s.i.	D 732
Deformation under load, 4000 p.s.i.,		D 621
77° F.	0.2%	
158° F.	0.3%	
Fatigue endurance limit (Wohler method), 1800 cycles/min., 73° F., 50% RH	2000 p.s.i.	—
Water absorption, 24 hr. immersion	0.2%	D 570
equilibrium 73° F.	0.35%	
equilibrium 212° F.	0.58%	

Thermal properties		
Heat distortion temperature	264 p.s.i.: 280-290° F.	D 648
	66 p.s.i.: 283-293° F.	D 648
Mold shrinkage	0.005-0.007 in./in.	D 955
Thermal conductivity	4.6×10^{-4} cal./sec. cm.^{2} (°C./cm.)	—
Coefficient of linear thermal expansion	7×10^{-5} in./in. °C.	D 696
Flammability	Self-extinguishing	D 635
Brittle temperature	$< -135°$ C.	D 746
Specific heat	0.30	Bulletin 157

Electrical properties	*—30° C.*	*—3° C.*	*23° C.*	*100° C.*	*125° C.*	
Dielectric constant						
60 cycles	3.12	3.14	3.17	3.15	3.13	D 150
10^6 cycles			2.96			D 150
Power factor						
60 cycles	0.005	0.004	0.0009	0.0009	0.0011	D 150
10^6 cycles			0.010			D 150
Volume resistivity, ohm-cm.	$>10^{17}$	$>10^{17}$	2.1×10^{16}	2.1×10^{15}	2.0×10^{14}	—
Arc resistance, stainless steel strip electrodes	10-11 sec.					D 495
Dielectric strength short time, 25° C.	3080 volts/mil at 3 mils 400 volts/mil at 125 mils					

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Consult the Subject Index and the Directory Index for further information on polycarbonate. See also the Plastics Properties Chart for information on properties and trade designations.

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Polypropylene

By F. Ranalli[*] and G. Crespi[*]

opments...Recent Developments...Rece

Unbreakable dinnerware (Rogers Plastic Corp.) molded from polypropylene has permanent gloss and permanent colors . . . will withstand temperatures up to 300° F.

A 9-oz. drinking cup (Crown Machine & Tool Co.), injection molded of polypropylene, has walls only 16 mils thick . . . is now being used in hospitals because it can be sterilized and is almost indestructible. . . . It sells for less than half the 11¢ glass tumbler which it is designed to replace.

Polypropylene yarn (*Reevon Series 800 Isotactic Polypropylene Monofilament,* Reeves Bros., Inc.) has many potential uses . . . in rope, wet and dry filter elements, and fabrics.

Rope (Plymouth Cordage Co.) manufactured from polypropylene filaments is significantly stronger, longer wearing, more heat-resistant, and less slippery than polyethylene rope . . . has the desirable chemical resistance, rot resistance, floating quality, and low stretch of polyethylene rope.

General-purpose polypropylene (*Pro-fax 6511J,* Hercules) features light color, transparency, heat stability. . . . Another (*Pro-fax 6512J,* Hercules) offers long-term stability at elevated temperatures.

Unoriented polypropylene film will soon be in production (by AviSun at Marcus Hook, Pa.) . . . cost is expected to be lower than cellophane, since the yield of polypropylene will be around 30,500 sq. in./lb. of resin compared to 21,000 for cellophane.

Isotactic polymers are made up of giant molecules characterized by an exceptional regularity of their structure. They were discovered by Prof. Giulio Natta of The Polytechnic Institute, Milan, Italy, and are produced by means of special catalytic systems called stereospecific; they have the property to selectively direct polymerization in such a way as to predetermine the final configurations of the polymeric molecules.

The first isotactic polymers investigated by Prof. Natta were polyalphaolefins. Among these, polypropylene was the first to reach commercial production. In fact, isotactic polypropylene thermoplastics were first produced on an industrial basis by Montecatini (under the trade name of Moplen) as far back as Sept., 1957.

Polypropylene shows promise in areas not now open to plastics because of economic reasons or property limitations. Application examples include: pipes; fittings; valves; packaging films and sheets; heat-sterilizable bottles; carboys; cable insulation; battery boxes; refrigerator parts; toys; radio cabinets; household articles such as buckets, basins, and bassinets; spools and other parts for textile machinery; impellers and casings for pumps; and automobile steering wheels.

Characteristics

The principal factors which influence the physical and mechanical properties of polypropylene are: 1) Content in isotactic polymers (isotacticity index). 2) Average molecular weight (melt index). 3) Distribution of molecular weights.

A simplified method for characterizing the polymer from the standpoint of its stereoisomeric composition is by extraction of the polymer with boiling *n*-heptane. The percent residue of this extraction is considered the isotactic polymer content and is called "isotacticity index." The molecular weight and the amount of the amorphous part of the polymer influences over-all properties, but for strictly practical purposes the physical properties can be considered as a function of the isotacticity index.

The average molecular weight of the polymer can be obtained from measurements of the intrinsic viscosity of the polymer in solution (usually in tetrahydronaphthalene at 135° C.). As a measure of the average molecular weight, the melt index can be determined according to A.S.T.M. D-1238 at 190° C. but under a load of 10 kg.; this index gives direct indication of the rheological properties of the polymers in the molten state.

The distribution of molecular weights in the polypropylene polymer is not yet known with sufficient accuracy. It can be assumed, however, that the distribution has the same characteristics for various batches of polymer prepared under similar conditions.

A summary of physical properties of polypropylene and the effects of variations in isotacticity and molecular weight (as molecular weight increases, melt index decreases) is given in the eight panels of Fig. 1, p. 143. Effects are discussed in more detail below.

Properties

Isotactic polypropylenes are colorless and odorless. With a specific gravity of 0.90 to 0.91, they are among the lightest plastics available. Their physical properties, directly attributable to their molecular structure, depend not only on the amount of isotactic polymer, but also vary with the type of crystalline aggregates which are formed during processing.

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[*] Montecatini Soc. Gen., Via Turati 18, Milan, Italy.

Recent Developments and References were prepared by the editors.

Slow cooling from the molten state fosters maximum growth of crystals which aggregate in coarse spherulitic structures; fast cooling gives chiefly crystallites and only a few single spherulites of limited dimensions.

When subjected to an external load, isotactic polypropylenes behave as typical crystalline polymers having a low second-order transition temperature. The materials first undergo elastic deformation up to the yield point; beyond this, a practically irreversible plastic deformation takes place up to break point. The stress-strain curve (at 22° C.) is chiefly influenced by: a) isotacticity index; b) average molecular weight (melt index); and c) deformation rate.

Yield point

The yield strength of typical commercial polymers increases when crystallinity increases. The isotacticity index influences the degree of crystallinity and therefore plays an important role in determining end properties.

The average molecular weight of the polymer also influences the yield strength, which decreases as molecular weight increases. With the same isotacticity index, the polymers having higher molecular weight (i.e., having a lower melt index) are less crystalline. The variation of yield strength versus the two parameters is shown in Fig. 1 (A).

A small positive variation of the isotacticity index leads to a remarkable increase of the yield strength, and since the yield stress can be measured with sufficient accuracy, it can be used to characterize the crystallinity of the polymer under examination. The elongation corresponding to the yield point usually ranges between 7 and 10 percent.

For sufficiently rapid stresses, up to values of 60 to 70% of the yield strength, polypropylene possesses an elastic behavior and undergoes hardly any permanent deformation when stress is removed.

Breaking point and total elongation

The breaking point of polypropylene depends on the ability of the sample to be stretched more or less completely until it attains that orientation stage which renders it extremely resistant.

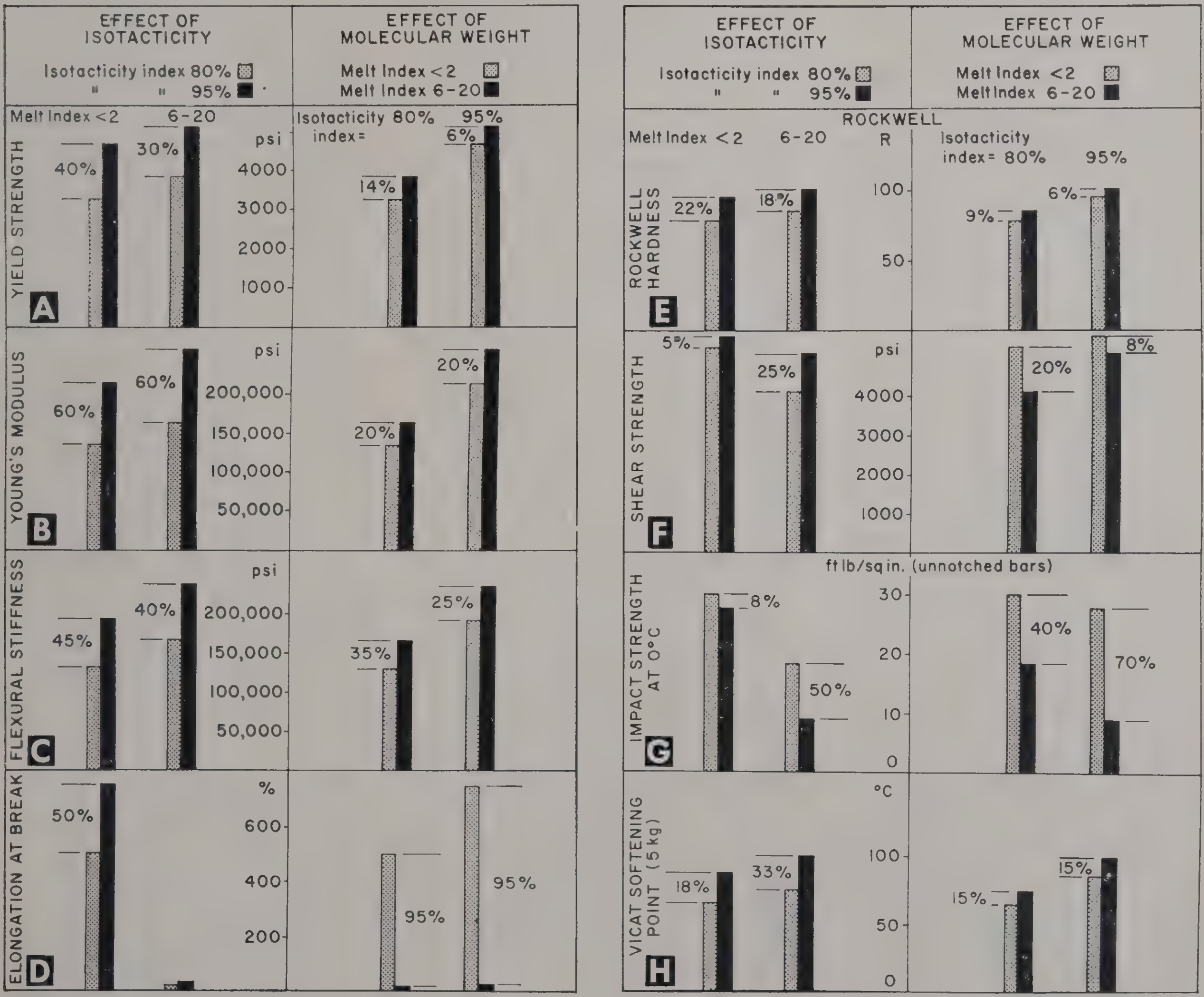

FIG. 1: Summary of effects of isotacticity and molecular weight on physical properties of polypropylene

TABLE I: Yield strength of polypropylene at 212° F.

Isotacticity index %	*Melt index*	*Yield strength at 212° F. as % of yield strength at 68° F.*
83	1.2	30.5
89	1.1	32.6
95	0.6	34.2
81	5.6	33
86	3.8	34.4
95.5	3.1	36.2
76	20.0	34.1
88	15.0	34.5
96	12.0	39.5

This ability is directly related to the average molecular weight of the polymer. (See Fig. 1, D).

A decrease in the isotacticity index gives higher elongations without giving an increase in the tensile strength. Total elongation at break, and, in general, all the characteristics of the stress-strain curve, depend remarkably on the rate of strain to which the sample is subjected.

Shear strength

The shear strength increases with the increase of both percent of isotactic polymer and average molecular weights. Its numerical value is higher than that of the tensile strength. Figure 1 (F) shows values of this property as a function of both isotacticity and melt index.

Flexural stiffness

Flexural stiffness (A.S.T.M. D-747) increases when isotacticity index and melt index increase. The influences of these two variables on flexural stiffness are very similar to that exerted on yield strength and are summarized in Fig. 1 (C). For isotactic content near 100%, the value of flexural stiffness approaches 227,000 p.s.i. which can be considered as a maximum value for polypropylene.

The relationship between surface hardness and isotacticity index, as in Fig. 1 (E), is quite similar to that observed for yield strength.

Abrasion resistance

This property can be measured by vertically pouring a given amount of Carborundum (80 mesh) over a plate of the material under examination placed at 45° to the perpendicular.

The measure of abrasion is determined optically and expressed in percent of brightness of the abraded zone. Abrasion resistance increases with the increase of the isotactic polymer content. Polypropylenes generally show an abrasion resistance lower than that of polymethyl methacrylate and PVC, but higher than that of polystyrene and polyethylene.

Impact strength

For polypropylene, the impact strength is influenced by several factors. Generally it can be considered as falling between that of high-impact polystyrene and that of high-density polyethylene.

The factors which most influence impact strength are: 1) Average molecular weight (melt index). 2) Isotacticity index. 3) Type of crystallization. 4) Orientation of the material. 5) Temperature.

For an unoriented and unquenched polypropylene, it can be established that: a) Impact strength increases, as in Fig. 1 (G). b) Impact strength decreases as isotacticity index increases. This effect is more remarkable for low molecular weights and for an isotacticity index higher than 90%. c) The influence of temperature is fundamental, especially in the range between 15 and 100° F. Over 100° F., polypropylene has an extremely high impact strength; at 15° F., on the other hand, it is brittle.

If the polymer has a crystalline structure composed of coarse spherulites (obtained by slow cooling of molten polymer), its impact strength is much lower than that shown in the case of small spherulitic structures which are obtained, for instance, in sheets quickly quenched in cold water.

Thermal properties

One of the most important characteristics of polypropylenes is their exceptional resistance to high temperatures.

Figure 2 shows the specific volume of polypropylene versus temperature. Two characteristic points can be noted: one of them lies at —30° F., and corresponds to the second-order transition temperature; the other one lies at 340 to 350° F. and corresponds to the crystallographic melting point or first-order transition temperature.

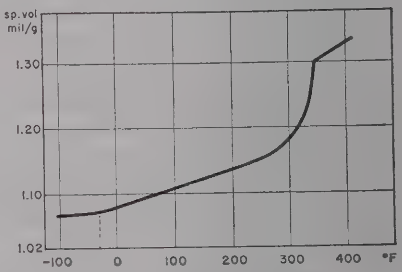

FIG. 2: Specific volume of polypropylene materials vs. temperature.

Parts molded of such polymers, when not subjected to mechanical stresses, maintain their dimensions without change up to temperatures approximating the melting point. Thus they can be subjected to repeated sterilization with steam. Further, the mechanical properties of the polymers do not undergo appreciable changes up to 300° F., enabling them to outperform most other commonly used polymers in temperature resistance.

Softening temperature

Vicat softening temperature (the temperature to which a needle of 1 sq. mm. section under a load of 5 kg. penetrates 1 mm. into the material under examination when the temperature is increased at a rate of 50° C./hr.) for polypropylene is an increasing function of the isotacticity index, as in Fig. 1 (H); an increase in molecular weight (decreasing melt index) has an opposite effect.

TABLE III: Solvent absorption *versus* isotacticity index

Exposure: 7 days at 20° C.

Solvent	*Weight increase, % isotacticity index*		
	89%	*95%*	*99%*
Gasoline	13.3	7.1	3.3
Benzene	12.1	10.7	7.3
Carbon tetrachloride	30.0	13.2	7.8

Yield strength at 212° F.

The yield strength for polypropylene at 212° F. is about 30 to 40% of that at room temperature and is higher in cases of high isotacticity indices or low molecular weights (See Table I).

Elastic modulus

The effects of increasing isotacticity and decreasing molecular weight (increasing melt index) on the elastic (Young's) modulus of polypropylene are shown in Fig. 1 (B). In studies of the effects of high temperatures on this property, it has been shown that the material has a remarkably high elastic modulus, even at temperatures in excess of 212° F.

Electrical properties

Since polypropylenes have an essentially nonpolar structure, they exhibit excellent electrical properties even at high frequencies. (See Table II).

Polypropylenes show practically no water absorption and the electrical properties remain virtually unaffected by humidity. Such excellent electrical properties, combined with good thermal and mechanical characteristics, result in superior electrical insulation. These properties do not vary with changes in molecular weight or isotacticity index, but can be negatively affected by the presence of impurities.

Chemical resistance

Polypropylenes show excellent resistance to a great variety of chemical reagents at temperatures much higher than those tolerated by other thermoplastic materials commonly used in the chemical industry. For instance, polypropylene resists 80% sulfuric acid and concentrated HCl up to almost 212° F. and can withstand saline solutions at temperatures over 212° F.

Resistance to solvents

Polypropylene is soluble at high temperatures in aromatic solvents and in chlorinated hydrocarbons. At room temperature, these solvents exert a swelling action. The resistance to solvents increases remarkably with an increase in isotacticity index (See Table III).

The solvent action is lower when the intermolecular forces are relevant as in a crystalline structure. Absorption of mineral and vegetable oils is extremely low.

Degradation factors

The molecular structure of polypropylene results in low resistance to degradation agents owing to the presence, along the chain, of tertiary carbon atoms linked to methyl groups. However, considering only the effect of heat in the absence of oxygen or of oxygenated functional groups in the polymers, there is no evidence of degradation up to 480° F., for several hours. Temperatures over 570° F., even for short times, leads to cracking phenomena with formation of gaseous products.

The reactivity of polypropylenes toward oxidizing agents obviously increases at high temperatures.

The intimate addition to the polymers of suitable anti-oxidant agents stabilizes polypropylene even when it is processed in the presence of oxygen at high temperature. Exposure of polypropylene to sunlight is possible when substances besides the anti-oxidant are added to shield the material against ultra-violet rays.

TABLE II: Electrical properties of polypropylene

	A.S.T.M. Method	
Dielectric strength,* 1/8 in., v./mil	D-149	770-820
Dielectric constant, 10^6 cycles	D-150	2.0-2.1
Dissipation factor, 10^6 cycles	D-150	0.0002-0.0003
Volume resistivty, ohm-cm.	D-257	10^{16}

*Short time test

Permeability to gases and vapors

For polymers of paraffinic nature, such as low- and high-density polyethylene and polypropylene, behavior toward gases and vapors is quite similar. The permeability coefficients vary chiefly in relation to crystallinity, but are always maintained within rather restricted limits; the order of magnitude remains unchanged.

References

Consult the Subject Index and the Directory Index for further information on polypropylene. See also the Plastics Properties Chart for information on properties and trade designations.

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Polyester (alkyd) resins

Polyesters are basically defined as the polycondensation products of dicarboxylic acids with dihydric alcohols. In the broad sense, however, the field of "polyester resins" includes many different types of resinous condensation products and collectively represents one of the fastest growing areas in the plastics industry. In 1958, for example, under the stimulus of expanded markets for boats and glazing, polyester resin sales reached an all-time high of 100 million lb. in sales.

The forms in which polyester resins are available and the uses to which they can be put are many and varied. Depending on the choice of raw materials or how the resin is manufactured, polyesters can be formulated to meet any one of a wide range of special needs.

The unsaturated polyester resins are one of the most important groups in the family. They are created by reacting a dihydric alcohol and a dibasic acid, either or both of which contain a double-bonded pair of carbon atoms. The alcohol and the acid are heated to sufficiently high temperatures to react, split out water, and form ester linkages. The double bonds in the unsaturated polyester resin thus formed render the material capable of subsequent cross-linking and this is generally accomplished by reacting the unsaturated polyester resin with a polymerizable monomer (e.g., styrene) under the influence of a special catalyst system (e. g., peroxide). In the reaction, the double bonds of the unsaturated polyester resin connect with those of the monomer (described as copolymerization or cross-linking) to form a thermoset which, when fully cured, is insoluble and infusible.

The versatile unsaturated polyester resins go into a number of end uses. Reinforced with glass, asbestos, synthetic, cellulosic, sisal, or other fibers, they can be fabricated into so-called "reinforced plastics" end products by hand lay-up, vacuum or pressure bag molding, matched metal molding, filament winding, and centrifugal molding. Mixed with the reinforcing fiber, filler, and a catalyst in a blender or dough mixer, the resins can also be formulated into putty-like or powdery premixes that can be molded in conventional compression or transfer presses. Closely related to the polyester premixes are those materials classified as alkyd molding compounds. These molding compounds, however, contain no highly volatile monomer and with reasonable precautions can usually be transported, stored, and handled like conventional thermosets. (For full discussion, see p. 78.) When diallyl phthalate is used as the reactive monomer with the unsaturated polyester resin, the polymerization can be arrested at a stage corresponding, in a sense, to the B-stage of a typical thermoset; polymers in this form represent the basis of commercial DAP molding compounds. The unsaturated polyester resins can also be cast into buttons, rods, tubes, dies, and other end products and, more recently, have been made available as a foam material that can be blown (using an outside blowing agent) in much the same manner as latex or vinyl foam is now handled. Unlike urethane, the foamed unsaturated polyester is poured, not foamed-in-place.

The second major group in the polyester family are the *saturated polyester resins*. When a saturated dihydric alcohol (i.e., containing no double bonds) is reacted with a saturated dibasic acid under controlled conditions, water is evolved and chain molecules having terminal hydroxyl or carboxyl groups result. These molecules are the saturated polyesters. They can undergo further inter-molecular condensations, but cannot be cross-linked as can the unsaturated polyester resins.

Certain saturated polyesters have become useful plasticizers often referred to as polymeric plasticizers. More often, special types prepared from ethylene glycol and terephthalic acid have found application in the textile fiber field (e.g., Dacron[1]) and as film (e.g., Mylar[1]).

A new and increasingly important use for these polyesters has been their reaction with isocyanates to produce *polyurethanes*. The isocyanates react with those polyesters containing hydroxyl groups to form urethane linkages and with those polyesters containing carboxyl groups to form amide linkages. In either case, CO_2 is evolved to produce the foamed polyurethane. Adipic acid and dimer acid polyesters are generally used.

Another basic group in the polyester family are the *alkyd coating resins*. Essentially three-dimensional polyesters produced mainly from phthalic anhydride, the alkyd coating resins are distinguishable from other polyesters in that they contain fatty monobasic acids as "oil modification" and are usually furnished in organic solvents. Before the war, the polyol component was almost exclusively glycerine, but at the present time other polyols, such as pentaerythritol, are widely used.

Unsaturated polyester resins

Much of the versatility of the unsaturated polyester resins lies in the wide selection of raw materials and basic processing methods available to meet the product characteristics that may be required.

The two basic ingredients of the unsaturated polyester resin—the dihydric alcohols and the dibasic acids—and the polymerizable monomer with which it is cross-linked are all capable of a good deal of variation.

Of the *dihydric alcohols*, the glycols of ethylene, propylene, 1, 3- and 2,3,-butylene, diethylene, and dipropylene—each with its own special characteristics—are most commonly used.

This article is based on copy submitted by W. O. Erickson, V. W. Ginsler, and H. A. Hoppens, Plastics and Coal Chemicals Div., Allied Chemical Corp., and H. J. West, Plastics and Resins Div., American Cyanamid Co., New York 20, N. Y. Copy on Diallyl Phthalate Resins submitted by Desmond M. C. Reilly, Food Machinery and Chemical Corp., Chemicals & Plastics Div., New York 17, N. Y.
Recent Developments and References were prepared by the editors.

[1] Trademark, E. I. du Pont de Nemours & Co., Inc.

The unsaturated *dibasic acid* is usually maleic anhydride or fumaric acid. Saturated dibasic-acid components, such as isophthalic, adipic and azelaic acids, and phthalic anhydride, are also used. And again, a good deal of variation is possible. A higher maleic content increases the resin reactivity and promotes rigidity at high temperatures, whereas increasing the phthalic anhydride gives a less exothermic resin with lower high-temperature rigidity. Linear dibasic acids, e.g. adipic acid, may be used to increase flexibility.

The *monomers* containing double-bond unsaturation that are reacted with the linear unsaturated polyester to achieve a three-dimensional structure when cured can be styrene, diallyl phthalate, vinyl toluene, methyl methacrylate, or triallyl cyanurate. These too have special properties to offer: diallyl phthalate, for example, in the formulation of molding compounds and triallyl cyanurate in developing superior heat resistance in the end product.

Other additions to the polyester formulation must also be taken into careful consideration. When properly formulated with an *inhibitor* (usually polyhydric phenols such as hydroquinone or tertiary butyl hydroquinone), the polyester solutions are stable enough at ordinary temperatures for all practical purposes. Generally, however, material to be stored in tanks, tank cars, or drums for prolonged periods should be protected from direct sunlight, heat radiation, or overheated warehouses. Stored under refrigeration, polyester resins can be stable for years.

Cure of the resin is initiated by the addition of a *catalyst* (usually an organic peroxide or hydroperoxide) and *activators* or accelerators (cobalt naphthenate, alkyl mercaptans, and dialkyl aromatic amines) are often used to promote the cross-linking reaction so that cure can be effected at room temperatures or short times obtained at higher temperatures.

The proper balance of all these ingredients will, of course, determine initial resin stability, catalyzed pot life, set time, and

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Relays for a data processing system (*305 RAMAC*, International Business Machines Corp.) are now molded from alkyd molding compounds (Glaskyd, Inc.), supplied in continuous rope form . . . accurate mold charges are made by cutting the compound to length. Free-flowing characteristics prevent distortion of small silver-plated inserts of the relays.

Reinforced plastics lifeboats (Welin Davit & Boat Div., Continental Copper & Steel Industries, Inc., and Lane Lifeboat & Davit Corp.) . . . approved by U.S. Coast Guard . . . can now be used on all American-flag ships. Hull and other structural plastics parts are made of glass-reinforced polyester resin (*Hetron 92*, Durez Plastic Div., Hooker Chemical Corp.), which is fire-resistant . . . styrene foam makes the lifeboat unsinkable.

Rapid cure of reinforced plastics at room temperature is possible with new polyester resin (*Paraplex P-463*, Rohm & Haas Co.) . . . advantages include fast wetting of glass fibers . . . rapid development of tack-freeness and hardness, even at low catalyst concentrations . . . freedom from sagging on vertical surfaces.

Diallyl phthalate resin (*Dapon*, Chemicals and Plastics Div., Food Machinery & Chemical Corp.) can be compounded into finished powders for compression or transfer molding. It can be colored in any shade . . . has almost no shrinkage in the mold or after use . . . does not take up water or moisture . . . has heat resistance for continuous service at 350 to 450° F.

For use in radomes, a new polyester resin (*Vibrin 136A*, Naugatuck Chemical Div., U.S. Rubber Co.) withstands sustained temperature of 500° F. . . . 1000° F. for short periods of time. Radar transmission is about ten times better than conventional polyesters.

Rapid cure characterizes a new polyester resin (*Laminac 4106*, American Cyanamid Co.), which has medium reactivity and low thixotropic viscosity.

Clear, flame-resistant polyester prepreg (*Cordoprĕg FRC*, Cordo Molding Products) meets Mil Specs when molded and is completely certified for both low temperature and 300° F. use . . . for bag or press molding . . . a wide range of tack from dry to wet with excellent flow characteristics.

Five grades of diallyl phthalate molding compounds are now being produced (Rogers Corp.). Two grades (*SD1-5* and *MDG*) have been approved under government specifications Mil-M-18794 and Mil-P-14E . . . three other grades (*SDG*, *SD1-30*, and *GD1-30*) are undergoing government qualification tests.

A new military alkyd molding compound (*Glaskyd 2051*, Glaskyd, Inc.) has been introduced . . . classified as MAI-30 and developed in cooperation with Bureau of Ships.

A technical grade of N,N-dimethyl-*p*-toluidine (*Accelerator DMT*, Wallace A. Erickson) is available for accelerating cure of polyester and styrene resins . . . most general-purpose polyester and styrene resins gel in about 1 min. at room temp. with use of 0.1% DMT and 1% benzoyl peroxide.

TABLE I: Properties of clear, cast polyester resins

Specific gravity	1.27
Hardness—Barcol	48
Rockwell—M scale	110
Tensile strength, at 25° C., p.s.i.	9,000
Flexural strength, at 25° C., p.s.i.	14,000
Flexural modulus, at 25° C. × 10^6, p.s.i.	0.82
Compressive strength, p.s.i.	23,000
Heat distortion point, °C. (A.S.T.M.)	105
Water absorption, 24 hr., at 25° C., %	0.30
Dielectric strength	
Short-time test at 25° C., v./mil	440
Step-by-step test at 25° C., v./mil	360
Dielectric constant at 60 cycles	3.4
at 10^6 cycles	3.3
Dissipation factor at 60 cycles	0.006
at 10^6 cycles	0.018

cure time. The cure itself proceeds in two distinct stages. The first is the formation of a soft gel (time of gelation is determined by composition and temperatures used). Immediately after gelation, the cure is rapidly propagated with considerable evolution of heat, which in a large mass of resin or under adiabatic conditions may carry the temperature up to 400 to 500° F. Complete cure can be obtained with no liberation of volatile materials.

General properties

The most important general properties typical of all polymerizable polyesters are: 1) Ease of handling. Polyesters in the uncured state are easily handled liquids. 2) They cure to a solid material with no liquid or gases evolved. Since the curing action is exothermic and the heat evolved aids in speeding the cure, polyester resins are among the most rapidly cured of the thermosetting resins. 3) Ease of coloring. Polyesters are light-colored liquids which can readily be pigmented to any desired color. 4) Excellent dimensional stability. 5) Good electrical properties. 6) Good physical properties.

Specialty type polyesters designed for specific applications can have one or a combination of additional properties: 1) good weathering resistance and light stability; 2) heat resistance—the use of monomers, such as triallyl cyanurate, in conjunction with highly unsaturated polyester bases, raises the operating temperature of polyester-fibrous glass laminates to 500° F.; 3) flame resistance; and 4) corrosion resistance.

Reinforced polyester resins

The primary field for the use of unsaturated polyester resin is the production of reinforced plastics. Any type of reinforcement can be used, although fibrous glass in the form of chopped fibers, roving, or woven or nonwoven mat is favored. (See "Fillers and Reinforcements," p. 436-453.) Since the reinforced polyesters are being used for a wide range of end products that vary in size from small electrical components to huge boat hulls, a number of different fabricating techniques are available.

The *hand lay-up* method is generally used for making large shaped articles such as radomes, wing sections, fairings, fins and wing tips, missile noses, and other products for the aircraft, electronic, marine, and missile industries. Either a male or female mold can be used. The polyester-fibrous glass laminates are laid up against the mold. Generally, a bag of impervious material is placed over the laminate and either vacuum or pressure is used to hold it in place during cure. Curing can be at room or elevated temperatures. Production is slow, but the technique is versatile enough to turn out radomes up to 36 ft. in length and boats up to 24 ft. long, as well as various types of huge storage tanks. (See "Bag Molding," p. 481.)

Preform or mat molding in heated matched-metal molds is used to turn out such commercial products as cafeteria trays, tote boxes, chairs, laundry tubs, washing machine tubs, automotive parts, luggage, and boats. The mat or preform is placed in the heated mold, the catalyzed polyester is poured in, and closing the mold forces the resin throughout the reinforcement. Conventional molding cycles are 2 to 4 min. at 220 to 260° F. and 50 to 200 p.s.i. (See "Matched-Metal Molding," p. 483.)

Premix molding provides a rapid method of making less critical parts at considerably lower cost than mat or preform molding. It makes possible the molding of parts with varying wall thicknesses, intricate contours, and molded-in inserts. Typical applications include: electrical equipment parts, refrigerator striker plates, automotive heater ducts, automotive air conditioner parts, and automotive garnish moldings (window frames). In this method, resin, reinforcement, filler, and catalyst are mixed in a dough-type mixer. Typical molding cycles are ¾ to 2 min. at temperatures from 270 to 300° F. and at pressures from 500 to 1500 p.s.i. (See "Premix Molding," p. 491.)

Other miscellaneous fabricating techniques are available, such as *continuous laminating* generally used for turning out flat or corrugated building panels with good weathering resistance, ease of coloring, and good physical properties. These sheets are made in light transmissions varying from 5 to 80% and are used primarily as skylights, industrial glazing, and awnings. For making spherical shapes for use as water softener tanks, diesel tanks, jet assist tanks, etc., *filament winding*, in which the reinforcing fiber is passed through a resin bath and wound up on a rotating mold, and *centrifugal molding*, in which a hollow mandrel is lined with glass mat and rotated while the polyester resin is being fed into it, are also available (see p. 486 and p. 489).

Diallyl phthalate resin

Diallyl phthalate, $C_6H_4(COOCH_2CH:CH_2)_2$, is a difunctional monomer which with heat and an appropriate catalyst undergoes addition polymerization. When the polymerization is about 25% complete and the viscosity is about 600 centipoises, the material gels. Further heating converts this soft gel to a hard, infusible, insoluble solid. During this process there is a shrinkage of 11.8%, but no loss in weight and no volatile material is given off.

Recently, the use of all-allylic thermosetting polymers based on diallyl phthalate prepolymer have been widely developed. One such prepolymer (Dapon[2] resin) is commercially available as a dry free-flowing white powder.

Diallyl phthalate resin is a relatively linear partially polymerized diallyl phthalate which softens and flows under heat and pressure (as in molding and laminating) and cross-links to a three-dimensional insoluble thermoset resin during curing. Unlike other thermosetting resins, it undergoes an addition polymerization in the presence of a peroxide catalyst. No volatile fragments (such as water) are released during the curing reaction. In view of the fact that the diallyl phthalate has been polymerized to the point where virtually all the change in specific gravity has taken place in making the resin, there is virtually no further shrinkage in final cure.

Diallyl phthalate resin finds ready application in molding compositions, resin blends for many purposes, and in industrial and decorative laminates. The material offers superior electrical properties (and retention of electrical properties), excellent dimensional stability, considerable processing advantages, resistance to 400° F., low moisture absorption, resistance to solvents, chemicals, staining and wet and dry abrasion, absence of corrosive vapors, good surface finish and availability in pastel colors with good color retention at high temperatures.

Molding compounds: For plastic molding purposes, diallyl phthalate resin is compounded (with diallyl phthalate monomer and various fillers) into finished thermosetting materials which can be molded by compression and transfer molding on standard equipment. Wet or dry compounding methods can be used.

Currently, the main uses of diallyl phthalate resin molding compounds are in electrical and electronic parts, including connectors, resistors, capacitors, and insulators where its electrical and dimensional advantages are most significant. Its uses are also being developed in such areas as colored appliance and tool handles and dinnerware and trays.

Resin blends: Diallyl phthalate resin acts as a cross-linking agent with unsaturated polyesters. It may be incorporated into the polyester at the time of manufacture or added on the job during compounding. Often it is advisable to use combinations of diallyl phthalate resin and monomer to achieve the correct viscosity. Resin blends of diallyl phthalate have many uses in the fields of coatings, castings and adhesives where the low shrinkage and excellent thermal and chemical characteristics of the material offer distinct advantages over competitive materials.

Laminates: With diallyl phthalate resin, the laminating industry now has a new and different resin with which to make moisture-proof, solvent-proof, and abrasion-resistant plastic laminates. These laminates can be applied directly on a variety of rigid core materials at very low laminating pressures.

The diallyl phthalate resin plastic surface can be used to give a permanent finish to high grade wood veneers or to upgrade low cost core materials by means of a patterned sheet. It is no longer necessary to use high pressure equipment or cores of high internal strength to make commercial quality laminates.

In the area of industrial laminates, diallyl phthalate and diallyl isophthalate resins are finding applications in glass cloth and glass mat laminates in the manufacture of tubing, ducting, radomes, junction boxes, aircraft and missile parts and other applications where the combination of resistance to heat and chemicals and high electrical properties are of special value.

Casting resins and foams

In the casting field, little if any reinforcing agent is used. Castings are made from both clear and filled resin by pouring the catalyzed resin into a mold. Curing can take place at room or elevated temperatures.

Castings are being produced for aircraft glazing. Filled castings are being used in electrical components. Decorative castings are the most rapidly growing segment of this field. Polyester buttons are produced in quantity.

Polyester resins used for casting are most often comparatively thin liquids, frequently custom formulated to fit specific end requirements. Resins which have a low shrinkage and a low exotherm during cure are recommended for casting in order to obtain crack-free and strain-free casting. Also available are filled polyester resins which come in thicker forms, resembling batter, for pouring into molds. Some polyester compounds can be cured catalytically without applying heat. Generally, however, baking is done in a closed mold to avoid contact with air

TABLE II: Characteristics of polyester-glass cloth and mat laminates

	¾ oz. mat laminate ⅛ in. thick, resin 65%	*12-ply glass cloth ECC 181-136, resin 40%*
Tensile strength, p.s.i.	12.500	47.500
Flexural strength, p.s.i.	24000	54000
Flexural modulus, p.s.i.	0.79×10^6	3×10^6
Impact strength, notched Izod	14	18
Heat distortion temp., °C.	300	300
Rockwell hardness, M scale	105	105
Water absorption, 24 hr., 25° C.	0.40	0.45

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[2] Trademark of Food Machinery and Chemical Corp.

during the cure which may cause surface softness. High dielectric strength, heat resistance, and ability to form a secure bond with other materials without adverse effect on these materials have made the liquid polyester popular in the manufacture of electrical and electronic products, parts, and assemblies, particularly for potting.

Saturated polyester resins

Among the three major outlets for saturated polyester resins are: plasticizers, fibers and films, and urethane foams.

Plasticizers: A number of polyester plasticizers are available commercially. In general, they are saturated resins of controlled molecular weight. The polyester plasticizers are more viscous and, because of their low volatility, are more permanent than other esters used for plasticizers. They may be used in both organic coatings and plastics.

Fiber and film: A special type of saturated polyester prepared from ethylene glycol and terephthalic acid has found application in the textile fiber field and as film. Clothing fabric woven with fibers (Dacron) of this polyester has good wear resistance and laundering characteristics. The film (Mylar) features well-known tensile strength and tear resistance and is used in electrical and packaging applications.

Polyurethane resins: Other saturated polyesters with lower molecular weights and differing compositions are entering the rapidly expanding field of polyurethane resins. The polyesters are used in conjunction with diisocyanate compounds to form foams and elastomers as well as coatings. For a full discussion of these materials, see "Isocyanates," p. 119, and "Foamed Urethanes," p. 286.

Saturated polyesters and diisocyanates of appropriate composition can also be reacted to form polyurethane elastomers capable of being cross-linked, by reaction with suitable agents, to form tough rubber products.

Alkyd coating resins[1]

Polyester resins used in organic coatings are usually known as alkyds. Alkyds are distinguishable from other polyesters in that they contain fatty monobasic acids as "oil modifications" and are usually furnished in solvents. Because of popular usage, these polyester resins will be referred to as alkyds.

The predominant group of alkyd resins used in the manufacture of surface coatings employs phthalic anhydride as the main polybasic-acid constituent and such polyhydric alcohols as glycerol or pentaerythritol. Other polyhydric alcohols, such as glycols, di- or tri-pentaerythritol, sorbitol, or trimethylolethane, can be used to emphasize special resin properties. In addition to the polybasic acid and polyhydric alcohol components, alkyd resins for protective coatings are modified with oxidizing or nonoxidizing fatty acids derived from vegetable and, in some cases, marine oils.

TABLE III: Modifiers for alkyd resins

Modifier	*Advantages contributed*	*Disadvantages contributed*
Rosin	Fast drying Hardness Mar resistance	Yellowing Poor exterior durability
Phenolic	Hardness Solvent resistance Alkali resistance	Yellowing Poor stability
Styrene	Fast drying Light color Color retention	Poor solvent resistance Poor stability Fair exterior durability
Silicone	Heat resistance Hardness Resistance to thermal shock	Cost Higher curing temperature
Acrylics	Fast drying Adhesion Color retention	Cost Limited compatibility with amines

Oil-modified alkyd resins of the air-drying type cure by oxidation of their drying oil constituent. In the case of the baking type, in which the oil modification may be oxidizing or nonoxidizing, the alkyds cure by heat alone or by co-condensation with alkylated amino resins in the presence of heat.

Quantitatively and qualitatively, the oil modification of alkyd resins produces profound effects on the properties of these products. Alkyds generally contain from 30 to 70% of oil and, depending on their specific range of oil content, are classified approximately as follows:

Classification	Oil content %
Short-oil	30-46
Medium-oil	46-56
Long-oil	56-70

Short-oil alkyds: Short-oil alkyds contain fewer of the aliphatic, solvent-tolerant, fatty-acid chains in their molecular structure, and, hence, are prone to be incompatible in aliphatic solvents. These alkyds are supplied as solutions in aromatics, such as xylene or toluene. The short-oil alkyds that are modified with nonoxidizing oils, such as coconut or castor oil, are used as plasticizers in cellulose nitrate lacquer formulations to contribute the necessary properties of adhesion, flexibility, durability, and color retention to modern automotive and other fast-drying industrial lacquer finishes. Short-oil, nonoxidizing alkyds are also used extensively with urea and melamine resins in baking enamels and yield exceptionally hard, tough finishes for refrigerators, washing machines, home freezers, and many other similar types of home appliances.

Short-oil, oxidizing alkyds based on soya, dehydrated castor, or cottonseed oils have a broad base of utility in industrial baking finishes of all types. In conjunction with acid-catalyzed urea resins, they have also found successful application in forced-dry, wood-furniture finishes that are superior in abrasion resistance, impact strength, and durability to oleoresinous varnishes or cellulose nitrate lacquers.

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[1] Prepared by D. C. Davis and L. Campanaro, Plastics and Coal Chemicals Div., Allied Chemical Corp.

Medium- and long-oil types: Medium- and long-oil alkyds that are soluble in mineral spirits are modified most frequently with oxidizing oils and are used in brushing-type, air-drying finishes. Many government specifications call for alkyds of this group and most of the familiar household paint products, such as alkyd, flat wall-paint, 4-hour high-gloss enamel, and porch, floor, and deck paints, are manufactured, at the present time, from either the medium- or long-oil type alkyd resins.

Availability of "odorless" and "low-odor" mineral spirits has permitted development of medium- and long-oil alkyd resin solutions in these solvents for interior alkyd-based flat paints and gloss enamels that are free from obnoxious odors. Long-oil and extra-long-oil alkyds at 100% solids are also increasing in usage as modifiers for various water-dispersed latices and as components of exterior house paints.

Modified alkyds: Oil-modified alkyd resins may be modified further by processing with other materials for the emphasis of special properties. Common modifiers are rosin, phenolic resins, styrene, and silicones. Modification of alkyd resins with acrylics or epoxy resins give a group of copolymers that combine the properties of both materials. Fast drying resins with excellent adhesion to metals and excellent color retention are the result. Such additional modification, however, is usually a compromise in which some properties are gained and others lost.

Highly thixotropic alkyds have been developed by modification with polyamide resin. Paint products produced from polyamide-modified alkyds are unusual in appearance in that they are jelly-like, but are quickly reduced to ordinary consistency by mechanical agitation.

Non-phthalic alkyds: Rosin or terpenes, and maleic anhydride or fumaric acid undergo a Diels-Alder reaction and form a tribasic acid. This reaction product can be esterified with glycerol or fatty-acid glycerides to produce alkyd resins that exhibit properties superior to those of the varnishes manufactured by simply cooking maleic-modified ester gum with oils. Although these alkyds cannot be considered equivalent-quality substitutes for phthalic alkyds, they fit into a small sphere of utility for special applications.

Use of alkyd resins in the surface-coatings industry has risen considerably faster than the increase in paint production during the past 25 years. Alkyd resin production (solids basis) reached 241 million lb. in 1946 and went to 497 million lb. in 1955. The 360 million lb. produced in 1958 reflected the general business recession of the country. It is expected, however, that the alkyd coatings will continue to grow because of their versatility, uniformity, and economy.

Versatility: Alkyds, in general are better coatings than oleoresinous varnishes and are adaptable to a wide variety of air-drying and baking finishes for wood, metal, plaster, paper, and plastics. In addition, alkyds function as plasticizers for cellulose nitrate.

Uniformity: The growth of alkyd resin production has fostered development of a new scientific attitude in the paint and varnish industry. Careful chemical controls required for successful alkyd production have replaced the individual judgment of the varnish maker and a new order of uniformity has resulted.

Economy: Alkyd resins are low in cost. Their raw materials are available to the manufacturers in abundant supply. The efficiency of handling packaged, ready-to-use vehicles of high quality and wide scope represents a greater stride in progress than any that the paint industry has made throughout its entire history.

References

Consult the Subject Index for additional information concerning polyester (alkyd) resins. For specific information on low-pressure laminating, see p. 468; casting, see p. 728. See also the Adhesives, Coatings, Foamed Plastics, Laminates, Low-Pressure Laminating Resins, and Plastics Properties Charts for information on properties and trade designations. For sources of polyester (alkyd) resins, see the Directory Index, p. 1078. See also "Alkyd molding compounds," p. 78.

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Protein plastics: zein, casein

Some 20 alpha-amino acids are known to be constituents of proteins; hence there are that many possible monomers. The alpha-amino and adjacent carboxyl groups form the backbone of the polymers. The other groups form the side chains; these groups include amino, amide, carboxy, aliphatic hydroxy, phenolic, guanidyl, indole, imidazole, thiol, and disulfide. They are apparently spaced regularly along the chains and vary greatly in amounts in the different proteins. These are the reactive parts of protein molecules and are responsible for fundamental differences between proteins and for the extreme complexity of these natural polyamides.

The fibrous proteins (keratins, such as horn, tortoise shell, hoofs, claws, hair, and feathers) resist solution and deformation by heat. The globular proteins (casein, soybean, and zein) readily dissolve and are thermoplastic.

Potentially low-cost proteins include soybean, zein, peanut protein, and keratins. Molding powders can be made from the reaction product of keratin-containing horn powder, urea, and formaldehyde. Peanut protein is suitable for glue. Soybean and peanut are used as extenders of phenolic resin in plywood.

ZEIN

By D. M. Rathmann*

Zein, a product of the corn wet-milling industry, belongs to the class of aqueous alcohol-soluble proteins known as prolamines. Although first isolated from corn in 1821, zein did not become commercially available until 1939. Applications are based on its solubility in organic solvents and its film and fiber-forming characteristics. In 1958 a partially deamidated zein, soluble in weak aqueous alkalies as well as aqueous alcohols, became commercially available.

Like all proteins, zein is a naturally-occurring high polymer composed of amino acid groups united by peptide linkages. The high proportion of amide and non-polar side chains accounts for its solubility in many organic solvents.

Processing and fabricating

Solutions of zein in organic solvents or aqueous systems are adaptable to a wide range of coating, film, and fiber applications. As a general rule, a solvent for zein must contain at least one functional group of the hydroxyl, carboxyl, amide, or amine type. Zein is also soluble in the lower aqueous alcohols and lower glycols and glycol-ethers.

Secondary solvents, which will not dissolve zein but which enhance its solubility in a primary solvent, include lower ketones, aliphatic esters, chlorinated hydrocarbons, and the higher glycol-ethers. These materials are particularly useful because they permit modification of such properties of zein solutions as evaporation rate or viscosity. They also promote compatibility with various resins and plasticizers. Alcoholic solutions of zein tolerate limited amounts of diluents such as toluene, xylene, benzene and naphthas.

Although zein is insoluble in water, it is readily soluble in dilute aqueous solutions of strong alkalies at a pH of 9.5 to 11, but not in concentrated solutions of these alkalies. Weak alkalies such as ammonia and borax do not solubilize zein. The new deamidated zein is dissolved by both weak and strong alkalies at pH 7.0 and higher.

Useful aqueous systems of zein are prepared with ammonium or sodium resinates, or various synthetic detergents, such as the sodium alkyl aryl sulfonates. Methods have also been developed for the preparation of high solids emulsions containing resin, plasticizer, and zein.

General properties of zein

Molecular weight	about 25,000
Specific gravity (at 25°C.)	1.25
Isoelectric point	6.2
Dielectric constant	4.9-5.0
Decomposition point (°C.)	180-200

Plasticizers for zein compositions include higher glycols, sulfonamides, fatty acids, amides, esters, and amines.

Fusion resins are made by blending zein with natural or synthetic resins and plasticizers. As in the case of solvents and plasticizers, resins containing highly polar groups and a proper balance between polar groups and hydrocarbon residues are fully compatible with zein. Particularly useful are rosin, modified rosins (e.g., polymerized, hydrogenated, or dibasic acid modified rosin), terpene-phenolic resins, and alpha-pinene resins. Many materials that may be classified as incompatible have been incorporated into zein systems by the use of mutual solvents, plasticizers, and resins.

Mixtures containing 80 parts of either zein or deamidated zein and 20 parts of a bisphenol-A epoxy resin are suitable for coating applications. Films cast from this mixture are baked and cured at 150° C. for 30 min. or 200° C. for 10 minutes. The resultant films are resistant to solvents, boiling water and acids, have strong adhesion to glass and metal, and have excellent flexibility and toughness.

Increased tensile strength, greater toughness, and higher water resistance are imparted to zein compositions by curing with formaldehyde. Because few primary amino groups occur in the zein molecule, reaction with formaldehyde proceeds at a slower rate than is the case with proteins containing these groups. Curing is accelerated by catalysts (strong mineral acids or their ammonium salts) or by heat above 70° C.

Properties

Zein and deamidated zein are the only industrially available proteins soluble in organic solvents. This property gives these materials many fields of application not open to other proteins. Zein and deamidated zein are compatible with a wide range of natural and synthetic resins and plasticizers. In addition, zein is soluble in dilute aqueous solutions of strong alkalies, and is dispersed by various resinates and synthetic detergents. Deamidated zein is also soluble in aqueous solutions of weak alkalies.

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* Research Dept., Corn Products Co., Argo, Ill.
References were prepared by the editors.

Unlike most other proteins, zein is highly resistant to microbial attack. Films and coatings are tough, glossy, scuff-resistant, and greaseproof. Fibers have wool-like propties, high tensile strength, and notable resistance to acids, alkalies, and organic solvents.

Applications

Textile fibers (Vicara brand) have been produced from aqueous alkaline solutions of zein by extrusion into acidic-salt hardening baths and curing with heat and formaldehyde. Properties are described in the Fibers Chart, p. 554.

Composition cork is produced by mixing cork granules with a solution of zein and formaldehyde in a glycol-type solvent. By application of pressure and heat, the zein is cured and set to a water-resistant binder. This composition cork is suitable for use in gasket sheets and bottle cap liners. It has excellent flexibility, compressibility, and resistance to water, oil, and microorganisms, and does not impart any taste to beverages with which it is in contact.

Alcoholic solutions of zein and a compatible resin are particularly adapted to use as label and overprint varnishes which are tough, glossy, and scuff-resistant.

Highly grease-resistant and greaseproof coatings can be applied to paper and paperboard from solutions of either zein or deamidated zein. Suitable coating mixtures are organic solvent solutions of zein, resin soap solutions of either zein or deamidated zein, or weak alkali solutions of deamidated zein.

Zein or zein-resin mixtures dissolved in alcohol or glycol are excellent vehicles for flexographic, or moisture- or heat-set inks to which zein imparts the desirable characteristics of rapid solvent release, hot and cold scuff-resistance, hardness, and excellent pigment binding. The stability of flexographic inks is greatly improved by addition of wetting agents to the zein vehicles before pigment milling. Deamidated zein dispersed in water by ammonia with a suitable resin is widely accepted as a vehicle for water-based inks.

Fusion resins, made by blending zein with resins and plasticizers, may be pelletized or ground to powders and dissolved in solvents to give coating solutions, or mixed with fillers to form molding powders.

CASEIN

Formaldehyde-hardened casein plastics were developed in Europe and their manufacture began there about 1900. Commercial development in this country did not get under way until after the original patents had expired. The basic patents covering the production of a tough, insoluble horn-like mass from casein by the action upon it of formaldehyde were taken out by Krische and Spitteler, in 1900.[1]

Formaldehyde is the only agent which has as yet been economically successful in transforming casein into useable plastics. It is more accurate, therefore, to use the term casein-formaldehyde plastics. Reaction with formaldehyde undoubtedly takes place through the polyamide groups and results in a cross-linked polymer.

Casein also reacts with aluminum salts in water solution to produce a stiffer, more stable material than casein itself. The casein-alum, unlike the casein-formaldehyde, is thermoplastic, hence may be extruded or molded with heat and pressure. Immersion in water breaks down the complex, leaches out the alum, and leaves the original casein.

Casein can be modified by acetic, propionic, and *n*-butyric anhydrides to produce derivatives that can be molded into articles having greater resistance to water. However, this reduction in water uptake is not entirely beneficial, since it is accompanied by a decrease in the strength of molded casein articles.

Conventional processing involves mixing ground rennet casein with water, dyes, and pigments; further processing in a screw extruder; extrusion as rods, tubes, or ribbons; hardening by immersion in a 5% formaldehyde solution for periods varying from a few days to several months (depending upon the dimensions of the piece); and drying.

Casein-formaldehyde plastics have generally good impact strength, some elasticity, and properties characteristic of thermosetting materials. A wide range of color effects is possible. Hygroscopicity and dimensional instability, however, have been limiting factors to their extensive application.

Forms available

Casein plastics are available in sheets approximately 16 by 20 in. by 2, 3, 4, and 6 mm. in thickness; other thicknesses up to 12 mm. are made to order. Standard size rods are approximately 41 in. long in diameters from ⅛ to ¾ in. inclusive. Rods smaller than ⅛-in. diameter are ground to size. Tubes are made to order in diameters up to 1 in. with bores of various diameters. Disks are available in any desired size from ⅜ to 2½ in. in diameter, varying from 2 to 8 mm. in thickness.

Special forms include button blanks, loops, rings, buckles, beads, game counters, and pushbuttons, as well as handles and various similar items.

References

Consult the Subject Index for additional information. See also the Adhesives, Coatings, Fibers, and Plastics Properties Charts for information on properties and trade designations. For sources of these protein plastics, see Directory Index, p. 1078.

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[1] U.S. Patent 646,844; German Patent 127,942.

Silicones

By P. A. Goodwin*

The silicones form a group of synthetic materials whose chemical structure combines both organic and inorganic linkages to produce many of the most desirable properties of both. Silicones exist in a wide range of physical forms from simple mobile fluids, through greases and flexible rubbers, to hard, durable resins of complex structure.

The unique properties of silicones have qualified them for many applications in almost all major industries. Some of the more important applications for the different classifications of silicones are shown in Fig. 1, p. 155.

As a class, the silicones have the following outstanding properties: 1) stability at high temperatures; 2) retention of properties at extremely low temperatures; 3) resistance to weathering and oxidation; 4) good dielectric properties; 5) durable water repellency; and 6) chemical inertness. While most silicones show outstanding abhesive properties and are used as release agents, some are excellent adhesives for most materials.

Structure

The term silicone is generic for all organopolysiloxanes. Structurally, organopolysiloxanes are compounds containing a skeleton of alternating silicon and oxygen atoms with organic groups also attached to the silicon.

Physical properties of the silicones depend upon the nature of the organic groups, the ratio of organic groups to silicon atoms, the molecular weight, and the detailed molecular architecture. Silicones may be linear, branched, or cross-linked. Depending on these factors, a silicone may be a fluid, elastomer, or thermoset resin.

Production

Regardless of physical form, most silicone polymers are produced by the hydrolysis and condensation of organosilicon halide intermediates. The intermediates may be produced by various methods. Simplified examples are given in Fig. 2, p. 155.

Silicone fluids are short-chain polymers whose molecular weight is controlled by the monofunctional units included in the condensation as chain stoppers. Elastomers are linear polymers of high molecular weight that are capable of vulcanization after compounding with reinforcing fillers. Resins are produced in a reactive B-stage by partial condensation of di- and trifunctional monomers. They are cured by heat and catalysts.

Silicone fluids may be emulsified in water by conventional techniques to provide stable, aqueous emulsions. Compounding with finely divided fillers or stable soaps yields grease-like compounds.

Resin solutions may be milled with pigments in the same manner as organic resins to formulate paints and enamels. Alternatively, they may be combined with fibrous fillers for molding or used as bonding agents for glass cloth for laminating.

Elastomers are compounded with a wide variety of reinforcing fillers and vulcanizing agents in conventional compounding equipment to yield silicone rubbers of almost any desired combination of properties.

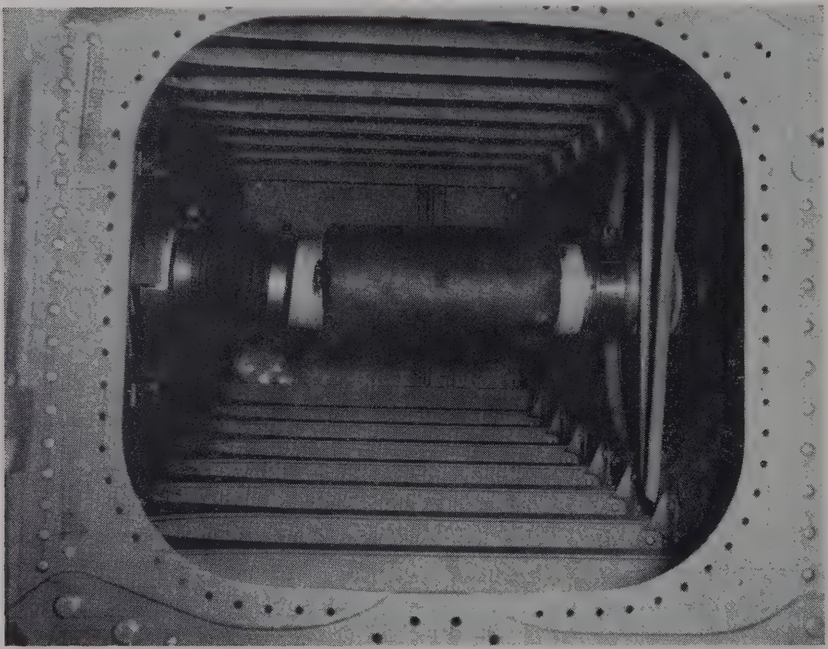
Molding compounds

Silicone molding compounds consist of inorganic fillers plus thermosetting silicone resins. They are adaptable to compression or transfer molding techniques and are characterized by good flow properties and low mold shrinkage.

Molded parts for mechanical or electrical applications are heat-stable and retain excellent physical and electrical properties in continuous service at high temperatures. They have heat distortion temperatures above 950° F. and flexural strength in the range of 14,000 p.s.i. at room temperature, 5000 p.s.i. at 400° F. Water absorption is about 0.1% after 24 hr. immersion. Arc resistance is in the range of 220 seconds.

Applications for silicone molded parts include connector plugs, coil bobbins, slot wedges, terminal boards, thermostat housings, heat

AIRCRAFT hot air duct, made of silicone rubber supported by glass cloth, will carry air at 700° F. and remain flexible at —120° F. (Photo, GE)



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*Manager, Technical Service, Silicone Products Dept., General Electric Co., Waterford, N. Y.
References were prepared by the editors.

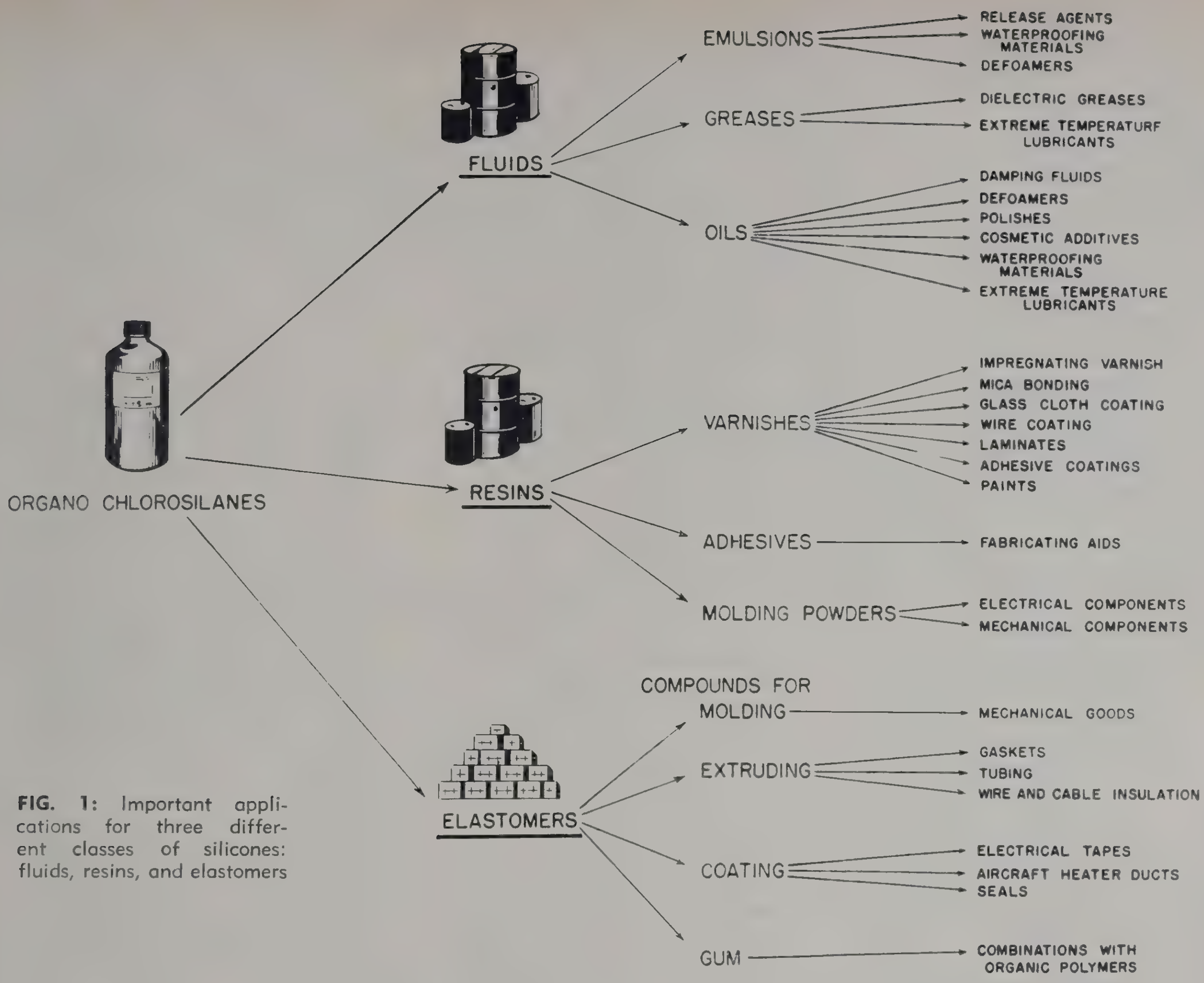


FIG. 1: Important applications for three different classes of silicones: fluids, resins, and elastomers

dams for jet engine afterburners, aircraft brake shoe barriers, and insulators on induction furnaces. They are also widely used in aircraft and guided missiles.

Laminating resins

Silicone laminating resins are available for either high-pressure or low-pressure fabrication techniques. Silicone laminates have exceptional high-temperature stability and retain a high percentage of their room-temperature strength at elevated temperatures. In high-temperature service, silicone-glass laminates retain a higher strength-to-weight ratio than do many light metals. They are characterized by excellent dielectric properties over a wide frequency range, superior arc resistance, and maintenance of good electricals even after prolonged immersion in water or at elevated temperatures.

Low-pressure laminates have flexural strengths of 30,000 to 50,000 p.s.i. at room temperature, 15,000 to 20,000 p.s.i. at 500° F. Dissipation factor after 24 hr. immersion in water is about 0.008 at 10^5 cycles.

High-pressure laminates retain a dielectric strength of 400 v./mil after 5000 hr. at 500° F. and a dissipation factor of 0.0044 at 10^5 cycles after 24 hr. immersion in water. Flexural strength at room temperature is in the range of 24,000 p.s.i.; at 500° F., about 4500 p.s.i.

Typical applications for silicone-glass laminates include rigid ducts for aircraft, coil forms and bobbins, transformer spools and spacers, terminal boards, and strips and slot wedges.

Foam resins

Ready-to-use foaming resins require no mixing or addition of catalyst or blowing agent. They expand on heating to produce rigid, low-density foams.

Silicone foams are heat-stable and nonflammable and combine the properties of thermal and electrical insulation. They can be used to cushion delicate instruments and equipment and to serve as lightweight structural fill for certain aircraft and missile components.

Silicone foams can be foamed

FIG. 2: Commercial processes for the manufacture of organochlorosilanes

Direct process

$2CH_3Cl + Si \rightarrow (CH_3)_2SiCl_2$

Grignard process

$2CH_3Cl + Mg \rightarrow 2CH_3MgCl$

$2CH_3MgCl + SiCl_4 \rightarrow (CH_3)_2SiCl_2 + 2MgCl_2$

Silicon hydride-hydrocarbon process

$3HCl + Si \rightarrow SiHCl_3 + H_2$

$SiHCl_3 + (C_2H_4) \rightarrow C_2H_5SiCl_3$

Wurtz process

$2CH_3Cl + SiCl_4 + 4Na \rightarrow (CH_3)_2SiCl_2 + 4NaCl$

in place or cast in sheets or blocks and machined, cut, or carved with conventional woodworking tools. (See also Foamed Silicones, p. 286.)

Release agents

Because of the incompatibility of most silicones with organic polymers and a wide variety of other organic and inorganic materials, silicones are widely used as release materials or parting agents for plastics, rubber, glass, and metal castings.

Silicone release agents are available as 100% silicone fluids, as water-dilutable emulsions, as greases, or as solvent solutions. They are chemically inert and heat-stable; therefore, there is no chemical attack on molds or molded parts and no carbonaceous build-up of release agent on the molds. Because of their low surface tension they give rapid, complete mold coverage, and because of their low volatility they reduce smoking and stay in place.

Use of silicone release agents provides parts of good appearance, both in surface finish and detail; long mold life; and low mold clean-out and maintenance costs. They are used on compression, injection, and transfer molds, extrusion dies, laminating plates or forms, and embossing rolls.

Other silicones, in the form of solutions or emulsions, are used as abhesive coatings for paper and paperboard employed for packaging gummy or sticky materials including pressure-sensitive adhesives, synthetic rubber, tacky polymers, and asphalt. The coatings are nonmigrating and do not contaminate the products packaged. They are also used as release-backings for adhesive products of all kinds, and in lining molds used for casting large slabs of polyurethane foams.

These coatings are applicable as one-side or two-side treatments on papers such as kraft, glassine, parchment, corrugated boxboard, and even on plastic films such as cellophane and polyethylene.

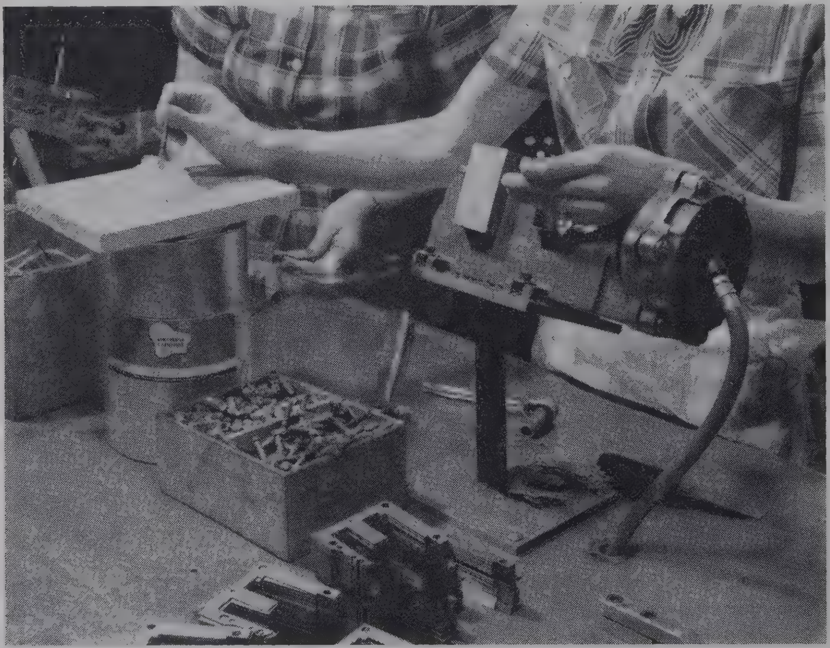
Lubricants

Silicone lubricants are available either as fluids or greases which cover an operating range from —100° to 500° F. and even higher in certain applications. They offer product designers the opportunity of creating new equipment of improved performance, using designs previously considered impossible because of the limitations of conventional lubricants. They reduce maintenance and relubrication costs and make permanent lubrication a practical reality.

Outstanding properties include thermal stability (over 500 hr. at 400° F. in air without gelation), low viscosity temperature coefficients, excellent stability to oxidation, and low volatility (less than 1% weight loss in 3 hr. at 200° C.).

Applications of silicone oils and greases include lubricating conveyors subjected to oven temperatures ranging to 500° F., rotating electrical equipment designed for either high- or low-temperature use, rubber seals, plastics bearings and bushings, and clocks and timers. Silicone greases are also used as dielectric compounds and release agents.

A TOUCH OF SILICONE COMPOUND forms excellent temporary bond to hold motor coils in position during varnishing and baking. (Photo, Dow)



Adhesives

Whereas most silicones are excellent abhesives, certain silicones are effective adhesives for a wide variety of materials. Some are resinous materials that cure to form a rigid bond; others are resilient or flexible products for bonding silicone rubber. Still another type of silicone adhesive is used to produce pressure-sensitive tapes for both mechanical and electrical applications.

Silicone pressure-sensitive adhesives remain tacky and flexible from —80° to 500° F. and they retain good adhesive properties for long periods at high temperatures. They provide excellent bonds to such materials as metals, glass, paper, silicone rubber, and plastics, including such difficult-to-bond resins as tetrafluoroethylene.

Applications for tapes made with pressure-sensitive silicone adhesives include electrical and electronic insulation, mechanical and electrical uses in aircraft, masking, and sealing high-temperature mechanical components.

Silicone rubbers

The commercial availability of silicone rubbers has given the design engineer materials that provide the peculiar properties of rubber under conditions not before possible:

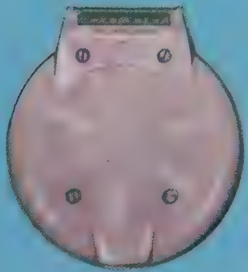
1) Resistance to temperature extremes far beyond the limits of all other known rubbers (—150° to 600° F.).

2) Superior resistance to compression set throughout its entire useful temperature range.

3) Unequaled resistance to ozone, aging, and sunlight and chemicals.

(*Continued on p. 165*)

PLEXIGLAS & IMPLEX
MOLDING POWDERS



ROHM & HAAS COMPANY • PHILADELPHIA 5, PA.

PLEXIGLAS
ACRYLIC PLASTIC
MOLDING POWDERS

PLEXIGLAS is a trademark which identifies certain acrylic plastic molding powders manufactured by Rohm & Haas Company. Due to the combination of gleaming beauty and excellent durability inherent in acrylic plastic, this molding material is used to add sales appeal and serviceability to a wide range of products. Manufacturers of cars, home appliances, lighting fixtures, personal accessories, and optical and electrical equipment use parts molded of PLEXIGLAS to meet their most exacting decorative and functional requirements.

CLARITY

The water-white clarity of Plexiglas moldings, plus the accuracy with which the material can be molded to critical tolerances, has resulted in the widespread use of Plexiglas lenses in cameras, slide viewers and other optical instruments.

BRILLIANT APPEARANCE

Plexiglas molded parts have gleaming, sparkling surfaces that enhance the colorful appearance of three-dimensional decorative medallions and nameplates. Decorations are applied to the protected rear surface of crystal-clear moldings.

DIMENSIONAL STABILITY

Plexiglas molded parts are noted for their freedom from shrinking or deterioration through long periods of use. The molding powders contain no plasticizers and have relatively low water absorption characteristics. Many types of precisely calibrated drafting instruments are molded of Plexiglas.

BREAKAGE RESISTANCE

Plexiglas imparts resilience and good strength to molded parts, enabling them to remain undamaged under rigorous service conditions. Molded letters and sign faces are typical of the applications that benefit from this resistance to breakage.

WEATHER RESISTANCE

Because Plexiglas is an acrylic plastic, unique among plastic materials in its ability to withstand outdoor exposure, it has become the standard material for parts such as tail light lenses on cars, shields on street lighting fixtures, and other applications subject to constant outdoor use.

ACCURACY OF MOLDING

The precise configurations of parts such as light-control lenses for lighting equipment can be achieved with complete accuracy by molding in Plexiglas. Molding accuracy can be sustained throughout large production runs.

CHEMICAL RESISTANCE

Plexiglas is not affected by alkalies, non-oxidizing acids, salt water, photographic solutions, and chemicals used in treating water. It is attacked by alcohol, strong solvents, and fire extinguishing solutions. Many types of valves used in manufacturing processes are molded of Plexiglas because of its chemical resistance.

CHOICE OF COLORS

A complete range of standard transparent, translucent and opaque colors are available in Plexiglas for integrally colored moldings such as pen and pencil housings. Custom-matched shades are produced for special color requirements on volume orders.

EASE OF DECORATION

Paints and vacuum metallized coatings can be applied to molded Plexiglas parts in efficient, high-yield production of three-dimensional, multi-colored moldings such as nameplates and trademark insignia.

IMPLEX HIGH IMPACT ACRYLIC MOLDING POWDERS

IMPLEX is a high-impact acrylic molding material developed by Rohm & Haas Company to provide outstanding toughness in injection molded parts. In addition to its high impact strength, IMPLEX exhibits the excellent general stability that is characteristic of acrylic resins. Its properties include low water absorption, good electrical characteristics, excellent dimensional stability, and resistance to staining and to attack by most chemicals.

The natural color of IMPLEX is off-white translucent, and it is also produced in many opaque colors. There are several formulations of the material, to meet requirements for different combinations of properties. IMPLEX contains no plasticizers—its properties are inherent in the plastic.

IMPLEX molding powders can be extruded into sheets, rods and tubes which can be heated and formed readily to complex shapes by vacuum, air pressure or with low-cost molds. Extruded material can be cut, drilled and cemented easily.

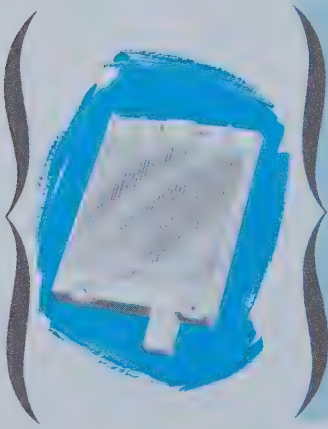
DIMENSIONAL STABILITY

The low water absorption and resistance to cold flow of molded Implex parts has resulted in their use where dimensional stability is important, as in lens barrel housings for slide projectors, threaded parts, and valve fittings.

NO UNPLEASANT ODOR OR TASTE

Food containers, particularly for vending machines and fountain dispensers, are molded of Implex because beverages and foods are unaffected by contact with the plastic material.

ACCURACY OF MOLDING



Complex shapes and intricate designs, such as brush dividers on card-tabulator business machines, and dials or valve parts, are molded accurately in Implex throughout long production runs.

STIFFNESS

Implex moldings resist flow under stress and this characteristic, coupled with their exceptionally high impact and flexural fatigue strength, has led to the widespread use of Implex for thin, high style heels on ladies' footwear.

HIGH SURFACE GLOSS

Smooth, lustrous surfaces imparted by Implex to housings, control knobs and carrying cases add sales appeal to many types of home appliances and personal accessories.

TOUGHNESS

The great strength and durability of Implex moldings lengthen the life of parts subjected to severe impact in use. A typical example is this shroud for an outboard motor engine, formed from Implex extruded sheet.

RESISTANCE TO STAINING

The strain resistance provided by Implex preserves the new appearance of piano keys, business machine parts, and other moldings exposed to grease, lipstick, perspiration, soft drinks, tea, coffee, etc.

CORROSION RESISTANCE

Implex withstands the effects of corrosive agents such as salt water, and is used for molded components of marine bilge pumps, collars on boat steering columns, and housings for running lights. It also resists deterioration from machine oils and acids.

average physical properties of PLEXIGLAS MOLDING POWDERS

(not intended for specification purposes)

Property	Test Conditions	Injection Plexiglas VS	Injection Plexiglas VM	Injection Plexiglas V	Compression Plexiglas Y
Refractive Index	A.S.T.M. D-542-42 —	1.49	1.49	1.49	1.49
Specific Gravity	A.S.T.M. D.-792-44T —	1.18	1.18	1.19	1.19
Tensile Strength	A.S.T.M. D-638-46T ¼″ specimen (0.2″/min.) Maximum, psi.	8000	9000	9000	7000
Flexural Strength	A.S.T.M. D-790-45T Span-depth ratio 16 (0.1″/min.) Maximum, psi.	15,000	16,000	16,000	12,000
Compressive Strength	A.S.T.M. D-695-44T (0.2″/min.) Maximum, psi.	14,500	15,000	17,000	12,000
Impact Strength	A.S.T.M. D-256-47T Izod Molded Notch (per inch of notch) ft. lbs.	0.5	0.4	0.4	
Rockwell Hardness	R & H P-20 ¼″ Ball, 100 Kg. Load	M—80	M—84	M—92	M—62
Light Transmission "As Received"	A.S.T.M. D-672-42T Total White, %	93	93	93	93
Effect of Accelerated Weathering on Appearance of Clear Material	LP 406b-6021 (240 hours)				
	Crazing	None	None	None	None
	Discoloration	None	None	None	Yellowed Slightly
	Warping	None	None	None	None
	Unmolding	None	None	None	None
Heat Distortion Temperature	A.S.T.M. D-648-45T 2°C./min.-264 psi.	75°C. (167°F.)	80°C. (176°F.)	91°C. (196°F.)	67°C. (153°F.)
Flow Temperature	A.S.T.M. D-569-48 —	132°C. (270°F.)	140°C. (284°F.)	158°C. (316°F.)	145°C. (293°F.)
Shrinkage from Mold Dimension	A.S.T.M. D-551-41 modified (Cold mold to cold piece) mils/in. 48 hrs.	4—7	4—8	5—8	
Deformation under Load	A.S.T.M. D-621-48T 2000 psi., 24 hrs. @ 50°C., percent	0.4	0.3	0.3	
Dielectric Strength	A.S.T.M. D-149-44 Volts/mil	500	500	500	500
Dielectric Constant	A.S.T.M. D-150-47T 1,000,000 cycles	2.3	2.3	2.2	3.0
Power Factor	A.S.T.M. D-150-47T 1,000,000 cycles	0.03	0.03	0.03	0.02
Loss Factor	A.S.T.M. D-150-47T 1,000,000 cycles	0.08	0.08	0.06	0.06
Arc Resistance	A.S.T.M. D-495-48T —	No Tracking	No Tracking	No Tracking	No Tracking
Flammability	A.S.T.M. D-635-44 Burning Rate, in./min.	0.5	0.6	0.7	0.7
Odor	—	None	None	None	None
Taste	—	None	None	None	None
Water Absorption	A.S.T.M. D-570-42				
	Wt. gain on 24 hours water immersion	0.3	0.3	0.3	0.3
	Dimensional change on immersion, percent	None	None	None	None

average physical properties of IMPLEX MOLDING POWDERS

(not intended for specification purposes)

Property	Test Conditions	Implex A	Implex B	Implex C	Implex F
Specific Gravity	D-792-44T	1.12	1.16	1.18	1.16
Tensile Strength	D-638-46T (0.2″ min.)				
	Maximum, psi.	5500	7300	7600	8000
	Modulus, psi.	225,000	300,000	325,000	325,000
	% Elongation (Break)	30	25	15	25
Flexural Strength	D-790-49T (Flatwise, 0.10″/min.)				
	Maximum, psi.	8700	11,500	12,000	12,000
	Modulus, psi.	280,000	360,000	360,000	360,000
Impact Strength	D-256-47T (Method B-5″ x ½″ x ¼″)				
	Charpy at				
	73°F., ft.-lbs.	30	20	13	20
	–13°F., ft.-lbs.	24	17	9	17
	Izod at				
	73°F., ft.-lbs./in. of notch	2.0	0.8	0.5	0.8
	–13°F., ft.-lbs./in. of notch	0.7	0.5	0.3	0.5
Compressive Strength	D-695-52T (0.05″/min.)				
	Maximum, psi.	7300	10,500	11,500	12,000
	Modulus, psi.	250,000	325,000	380,000	385,000
Rockwell Hardness	D-785-51 (Method A)	L—58	L—89	L—93	L—94
Barcol Hardness	R & H D-79	56	69	74	73
Heat Distortion Temperature	D-648-45T (2°C./min.)				
	264 psi.	169°F. (76°C.)	174°F. (79°C.)	174°F. (79°C.)	189°F. (87°C.)
	66 psi.	194°F. (90°C.)	185°F. (85°C.)	185°F. (85°C.)	207°F. (97°C.)
Flammability	D-635-44 (in./min.)	0.6	0.5	0.6	0.7
Mold Shrinkage	Mil/in.	4—8	4—8	4—8	4—8
Flow Temperature	D-569-48 Method A	320°F.	295°F.	285°F.	325°F.
Water Absorption	D-570-42 (24 hours immersion)				
	Weight gain, %	0.3	0.3	0.3	0.3

IMPLEX FORMULATIONS

IMPLEX A is recommended where maximum impact strength is required. It is the toughest, most flexible member of the Implex family.

IMPLEX B is recommended for use where high gloss and moderate impact strength are required. Implex B will flow more readily than Implex A particularly in thin sections.

IMPLEX C is recommended for use where maximum stain resistance and abrasion resistance are required but where high impact strength is not needed. Implex C was developed specifically for use in piano and organ keys.

IMPLEX F is recommended for use where high heat distortion temperature and moderate impact strength are required. Implex F is recommended for use in vending machine canisters containing beverages and powdered cream, sugar, etc. It has been approved by the National Sanitation Foundation Testing Laboratory, Inc.

For additional information on PLEXIGLAS and IMPLEX, and assistance in their use for specific applications, call or write any of these ROHM & HAAS COMPANY sales offices:

ATLANTA 9, GEORGIA
1430 W. Peachtree Street, N.W.
Telephone: Trinity 5-7808

BOSTON, MASSACHUSETTS
13 Eaton Court
Wellesley Hills 81
Telephone: Cedar 5-7134

CHICAGO 48, ILLINOIS
5750 W. Jarvis Avenue (Niles)
Telephone: Rodney 3-7000

CLEVELAND 13, OHIO
2012 W. 25th Street
Telephone: Prospect 1-3588

DALLAS 1, TEXAS
209 Browder Street
Telephone: Riverside 7-6369

DAYTON 2, OHIO
333 West First Street
Telephone: Baldwin 3-8513

DETROIT 35, MICHIGAN
20211 Greenfield Road
Telephone: Broadway 3-0674

KANSAS CITY 5, MISSOURI
1009 Baltimore Avenue
Telephone: Victor 2-6850

LOS ANGELES 36, CALIFORNIA
5657 Wilshire Boulevard
Telephone: Webster 1-1491

NEW YORK 1, NEW YORK
350 Fifth Avenue
Telephone: Longacre 3-4154

PHILADELPHIA 5, PENNSYLVANIA
Washington Square
Telephone: Walnut 5-9860

SAN FRANCISCO 8, CALIFORNIA
600 California Street
Telephone: Douglas 2-6664

ST. LOUIS 17, MISSOURI
1110 S. Brentwood Boulevard
Telephone: Parkview 7-7172

WASHINGTON 5, D.C.
734 Fifteenth Street, N.W.
Telephone: National 8-0847

IN CANADA
Rohm & Haas Company of Canada Ltd.
West Hill, Ontario

ROHM & HAAS COMPANY
WASHINGTON SQUARE • PHILADELPHIA 5, PA.

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Printed in U. S. A.

4) Good electrical properties which are maintained at elevated temperatures.

Silicone rubber materials are available in consistencies for molding, calendering, caulking, sponging, laminating, and wire coating. Dispersions are also available for coating operations. Commercial applications include:

Aircraft: Various airframe applications for low-temperature flexibility and engine components for high-temperature compression set and resistance to various fluids.

Appliances: For high-temperature compression set and maintenance of good electrical characteristics over a wide range of temperatures.

Electrical: In extruded insulation and insulation tape, both supported and unsupported, as well as in many molded and extruded parts such as bushings, seals, and spacers.

Miscellaneous: Other applications range from nursing bottle nipples to parts for handling hot glass, in which advantage is taken of general inertness to high temperatures and chemical attack.

The silicone rubber materials just described are cured using the high temperatures normally used for other types of rubber materials. There are also silicone rubbers which cure at room temperature with or without pressure. These materials are available as solventless pastes ranging from pourable fluids to pastes of caulking consistencies.

The room-temperature-curing silicone rubbers exhibit all the properties of the silicone rubbers described above and can be used where heat curing is impractical. One area in which they are being used is in mold making for plastics reproduction and plastics tooling, where they will give exact reproduction of surface detail and surface gloss. Other resin molding materials can be poured into a cured silicone rubber mold repeatedly even at high temperatures, cured, and released without using a mold release agent.

Other uses for these room-temperature-curing silicone rubber materials include high temperature sealing; potting and encapsulating; and in bonding to metal, glass, cured polyester epoxy, and silicone rubber, using a special primer.

RUBBER MOLD is sprayed with silicone mold lubricant for easier release, fewer rejects, and reduced mold-cleaning cost. (Photo, GE)

Miscellaneous

Silicone fluids are used in almost all flexible polyurethane foam formulations. Added in small percentages to the prepolymer or other ingredients at the time of foaming, the silicone stabilizes the foam during cure, prevents premature collapse, and provides a high degree of cell uniformity, especially in low-density foams.

Silicone resins, used in combination with inorganic materials such as glass, mica, and asbestos provide operation of electrical equipment at Class H temperatures with a permissible continuous "hot spot" of 180° C. Much Class H insulation will withstand long service at 250° C. Electrical applications for silicone resins include their use as dipping and impregnating varnishes, mica-bonding resins, saturants for glass-served wire, cloth-coating resins, and water repellents.

Silicones are among the most effective and versatile defoaming agents available, and silicone antifoams have found applications in many parts of the plastics industry. For example, silicone antifoams are used to suppress foaming during stripping of resin or rubber latices after polymerization, and to prevent the inclusion of foam in latex articles.

The addition of small quantities of silicone fluids to plastisol formulations has been reported to reduce blocking and improve the surface slip of finished items. It also facilitates de-aeration.

References

Consult the Subject Index for additional information concerning silicone polymers. See also the Adhesives, Coatings, Laminates, Low-Pressure Laminating Resins, and Plastics Properties Charts. For sources of silicones, see Directory Index, p. 1078.

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Styrene polymers and copolymers

Although polystyrene was discovered in 1839, it was not produced commercially until 1935. Since its rise in commercial availability and popularity, many improvements have been made.

Styrene monomer is the principal raw material from which styrene polymers and copolymers are made. Styrene may be polymerized alone or it may be copolymerized with other monomers by bulk, suspension, emulsion, or solution processes.

Advanced techniques in these polymerization processes and in compounding have resulted in the development of a broad range of styrene molding materials. Each offers specific physical properties and behavior characteristics that enable it to be used economically for producing parts to satisfy specialized service requirements in certain areas of use.

General-purpose polystyrenes

Many outstanding features are responsible for making polystyrene one of the most popular of plastics. It is among the lightest of present commercially available rigid plastics (specific gravity, 1.04 to 1.07). Because the basic resin is colorless, the polymer can be made crystal clear or in an unlimited range of colors from transparent to opaque. Excellent dimensional stability combined with negligible moisture absorption (even after long-term immersion) and freedom from warping or distortion within the thermal operating range of each grade make the polystyrenes useful where molding to close tolerances is required.

Polystyrene is relatively free from taste and odor, nontoxic when used in contact with food, and does not support growth of molds or fungi. Its resistance to corrosive chemicals and their aqueous solutions, such as acids (except oxidizing acids), alkalies, salts, and lower alcohols is outstanding. Electrical properties are exceptionally good.

GENERAL-PURPOSE POLYSTYRENE

Tensile strength, p.s.i.	5000-9000
Elongation, %	1.0-2.5
Heat distortion temp., °F.	150-195
Water absorp., 24 hr., ⅛ in. thickness, %	0.03-0.05
Notched impact strength, ft. lb./in. 77° F.	0.25-0.60
—40° F.	0.20-0.50
Luminous transmittance, %	0-93

According to A.S.T.M. D-703-56T, there are four basic types of polystyrene molding and extrusion materials. These are:

Type 1: A general purpose molding and extrusion material consisting of an unmodified form of polystyrene, with or without the addition of colorants and small amounts of lubricants, having a minimum distortion temperature of 175° F. (79.4° C.). (Note: heat distortion valves are those obtained using a ½ by ½ by 5 in. specimen.)

Type 2: A lubricated general-purpose molding and extrusion material consisting of polystyrene, with or without the addition of colorants, having a minimum heat distortion temperature of 165° F. (73.9° C.).

Type 3: A polystyrene molding and extrusion material characterized by improved resistance to thermal distortion and a minimum heat distortion of 185° F. (85° C.) with or without colorants and small amounts of lubricants.

Type 4: A lubricated polystyrene molding and extrusion material characterized by improved flow properties and having a minimum heat distortion temperature of 155° F. (68.3° C.) with or without the addition of colorants.

Applications: Disposable packaging for all sorts of merchandise, dispensing dishes, and utensils for foods. Refrigerator parts (e.g. crisper trays, meat keepers, butter dishes, etc.), emblems, signs and displays, and packaging applications of a more permanent nature. Toys, games, novelties, combs, brush-backs, wall tile, many housewares for use with cool foods, flower pots, and planters. Special compounds are used in phonograph records.

Heat-resistant polystyrenes

For satisfactory service in high-temperature atmospheres, e.g. in heavily illuminated display windows or in closed automobiles kept out in the sun, heat-resistant polystyrenes have proved their value. Parts molded of this heat-resistant material show good retention of dimensional stability in boiling water for short periods of time, but cannot really be called "boilable." Coincident with improved heat resistance, these grades have enhanced physical properties that often dictate their use where heat resistance is not in question. However, the transformation of the base polystyrene to a heat-resistant variation may sometimes involve sacrifice of other properties, e.g., color and crystal clarity, electrical loss factor, and low specific gravity. Manufacturers should be consulted for details.

As contrasted to easy-flow materials, the heat-resistant polymers reach moldable plasticity and set up in molds at higher temperatures. This characteristic requires molding machines with high plasticating capacity and high-injection speed. Good mold temperature control in the range of 160 to 200° F. is necessary for economical quality production. To realize the full potential in strength and heat resistance. however, annealing of molded parts may be required in some cases. Slow cooling after annealing prevents introduction of new thermal stresses.

In some cases, annealing only increases the instantaneous heat-distortion temperature of a piece when measured under load. It does not always increase the use temperature when the part is subject to long-time service at elevated temperatures under load.

This article is based primarily on information supplied by Koppers Co., Inc., Pittsburgh, Pa.

Other contributors: American Cyanamid Co., U.C. Plastics Co., Catalin Corp. of America, The Dow Chemical Co., Monsanto Chemical Co., and U.S. Rubber Co.

Recent Developments and References were prepared by the editors.

It is, sometimes, possible to run faster molding cycles with heat-resistant grades than with normal styrenes. Because setup is so rapid, these grades are especially adaptable to the molding of heavy sections. Because of their high-strength characteristics, heat-resistant grades are also often preferred for the extrusion of rods, tubes, profiles, etc.

Applications: With the same coloring and decorating potential as normal polystyrenes, the heat-resistant polystyrenes have been extensively used in table model radio cabinets, TV lenses or front panels and handles, illuminated jewelry packages, storage battery cases, camera housings, appliance panels and handles, illuminated signs and displays, fluorescent lighting fixtures, housewares to withstand unusual stress or hot food contact, and reels and spools for film and tapes.

Chemical-resistant styrenes

Specially modified styrenes have also been developed to have the chemical resistance needed by various household and industrial articles that must withstand contact with aromatic, aliphatic, and chlorinated hydrocarbons, organic acids and esters, essential oils, and fats.

This is achieved by modifying the base resin, usually with the addition of a moderate proportion of an organic nitrile, such as acrylonitrile. Some sacrifices in properties may be evident with the styrene-acrylonitriles as compared with the general-purpose polystyrenes.

HEAT- AND CHEMICAL-RESISTANT POLYSTYRENES

Tensile strength, p.s.i.	7000-12000
Specific gravity	1.05-1.11
Elongation, %	1.5-2.5
Heat distortion temp., °F.	180-235
Water absorp., 24 hr., 1/8 in., thickness, %	0.05-0.40
Notched impact strength, ft. lb./in., 77° F.	0.3-0.6
—40° F.	0.2-0.5
Luminous transmittance, %	0.90

Styrene-acrylonitrile, while not a high-impact resin, has mechanical properties superior to that of the ordinary polystyrenes. This results in greater practical toughness which, combined with clarity, accounts for many of the uses of the styrene-acrylonitrile resins.

Several molding grades, which differ principally in molecular weight, are available. The compounds of highest molecular weight usually possess the greatest mechanical strength, but they are lower in plasticity and, therefore, are less easy to mold. Compounds of lower molecular weight which can be molded with greater ease are available for those applications which do not necessarily require maximum mechanical strength.

Usually, electrical properties and water absorption are slightly impaired, as compared to normal polystyrenes.

Applications: Housewares (dishes, tumblers, and cutlery handles); hair curlers; pins; cosmetic packaging; fountain pen barrels; battery cases and radio cabinets; sight glasses for pressure oil systems and oil dispensing devices; and laboratory uten-

pments...Recent Developments...Rece

Amber polystyrene (*Dylene #4*, Koppers Co., Inc.) vials are being used as light-protective prescription containers (Glass & Closure Div., Armstrong Cork Co.) . . . white opaque polyethylene snap caps give a tight seal, can be removed easily, have flat tops for convenient marking.

Extruded styrene components for lighting fixtures and illuminated ceilings (Sheffield Plastics, Inc.) are guaranteed against ultra-violet light discoloration. Material used is modified styrene coated with a protective layer of a special ultra-violet absorbing agent *(Frost-White-X)* . . . shows no sacrifice of cold flow properties or dimensional stability.

Improved high-impact styrene well casing (*Carlon "T"*, Carlon Products Corp.) for rotary, auger, and driven wells, is easily installed . . . Because of light weight, no mechanical handling equipment is needed . . . Permanent joints are made quickly by a two-step solvent weld.

A styrene-methyl methacrylate copolymer molding material (*Zerlon 150,* Dow Chemical Co.) has excellent clarity, weatherability, processability, toughness, good strength, heat resistance, and light stability.

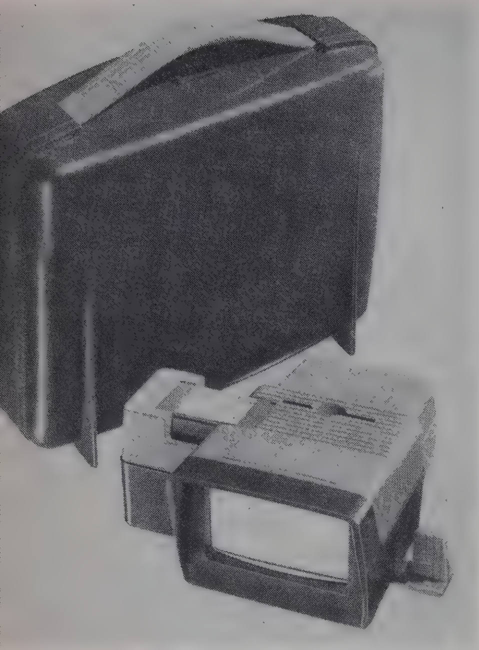
High-impact styrene molding material (*Fosta Tuf-Flex 289,* Foster Grant Co., Inc.) . . . intended specifically for shoe heels . . . lends itself to new doweling techniques for heel attachment.

"Low-static" styrene injection molding materials (*Lustrex Lo-Stat,* Monsanto Chemical Co.) practically eliminate electro-static fields that draw dust . . . can be handled like their equivalents in conventional styrenes.

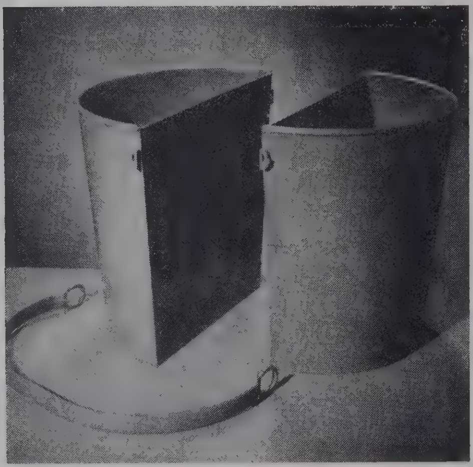
Styrene-acrylonitrile copolymer (*Fostacryl,* Foster Grant Co.) is almost crystal clear . . . requires only minimum use of dyes to counteract slight yellowing encountered in processing . . . resists acids and many other chemicals.

"Low-static" styrene injection molding materials (*Lustrex Lo-*Co.) is available for commercial use . . . clarity and dimensional stability make it useful for window envelopes and cartons, small bags and pouches, overwrap, high-gloss laminate for paper and high-impact plastic sheet.

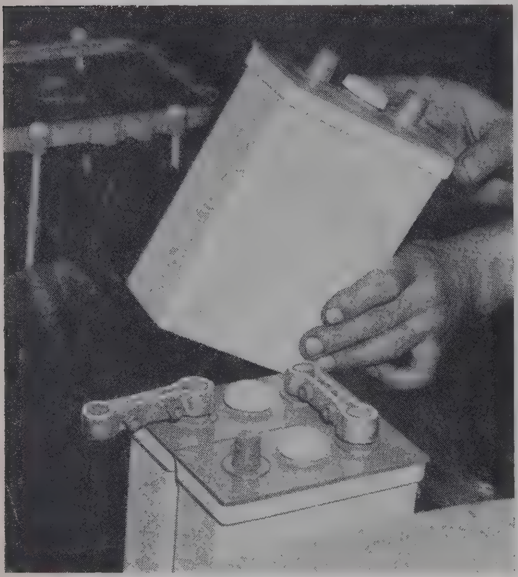
THERMOFORMED refrigerator door liners are being produced of rubber-modified styrene sheet on an automated production line that includes a sheet extruder, two rotary thermoforming machines, and handling equipment. Formed sheets are shown being conveyed from one of the forming machines (extreme right) to the press brake (left background), where they will be trimmed and punched



SLIDE VIEWER housing and carrying case are injection molded of polystyrene, as are also several parts of the slide magazine. Material is light in weight and amply strong for the application. Because of low production costs, simplicity of assembly, and elimination of finishing operations, the unit is more economical to manufacture than similar equipment using die-cast and fabricated metal parts



TAKE-APART BUCKET for household use is molded of high-impact polystyrene in identical halves that can be used separately or held together by the detachable handle. Together, they form a handy combination for holding soapy water in one half and rinse water in the other; separated, they can be used as "litter buckets" in automobiles



STYRENE COPOLYMER is used to mold the cases for replaceable cells in a new automobile battery design. The material was chosen for its light weight, acid resistance, and good electrical properties, plus the fact that it could be molded in the thin wall sections called for in the cell design

HOT-DISH COVERS, thermoformed from styrene copolymer sheet, have low thermal conductivity and therefore keep food warmer than the metal covers which they replace. They are also light in weight, durable, and resistant to soaps, detergents, and food acids. They are easy to clean and withstand normal dishwashing water temperatures

TABLE I: Properties of high-impact styrenes

	Modified styrene		*Acrylonitrile copolymer blends*
Property	*Med. and high impact*	*Very high impact*	
Specific gravity	1.05-1.11	0.98-1.10	1.01-1.10
Tensile strength, p.s.i.	7000-12000	3500-6500	3000-6000
Elongation, %	1.5-2.5	10-90	20-50
Flexural strength, p.s.i.	10000-17000	5000-7000	4500-11500
Izod impact strength, ft.-lb./in. of notch	0.25-0.5	0.5-10	0.4-12
Heat distortion temp., ° F.	160-190	150-190	170-195
Hardness (Rockwell)	R120	R50-R110	R60-R110
Molding qualities	Excellent	Very Good	Good

sils are a few of the applications for these specially modified styrenes.

Special styrenes—light stable

Normal polystyrenes do not resist outdoor weathering sufficiently to warrant use in permanent outdoor installations. Exposure to ultra-violet light from direct sunlight or artificial sources causes polystyrenes to develop a yellowish straw cast and eventually become brittle. Light-stable formulations which, by test under ultra-violet light sources, show substantial improvement in such behavior have, therefore, been developed. However, the degree of stability is still not so great that stabilized polystyrenes can be recommended for outdoor uses.

On the other hand, light-stable polystyrenes are finding increasing use in molded and extruded indoor lighting fixture diffusers, and in packaging to protect contents from discoloration or spoilage from ultra-violet light exposures. In some cases, improved light stability is achieved with some sacrifice of heat resistance or strength characteristics. In other instances, the light-stabilized formulations are slightly limited in colorability, making it difficult, for example, to produce clear translucent bluish white.

Special styrenes—glass reinforced

Fibrous glass-reinforced polystyrene is made for the production of strong, rigid pieces with superior dimensional stability. The normal method of manufacture is by injection molding. Compression molding or extrusion techniques ordinarily do not result in the entanglement and felting of the glass fibers which is necessary to realize the full reinforcing potential of the fibers. Compounds usually contain about 35% glass by weight. Some have been made up to 50 percent. The 35% compounds typically have the following properties:

Tensile strength, p.s.i.	**10,000-15,000**
Elongation, %	**0.75-1.02**
Heat distortion temp., °F.	**218-236**
Water absorption, %	**0.50-0.10**
Notched impact strength, ft. lb./in. of notch	**1.5-2.5**
Mold shrinkage, in./in.	**0.001**

Glass-reinforced polystyrenes are supplied either in slightly translucent to opaque colors or in an off-white natural that may be dry colored by the molder. Some decorative value can be achieved by mixing these polystyrenes with transparent, heat-resistant polystyrenes. Service or appearance requirements of certain applications may be satisfied by mixing the glass-reinforced polystyrene pellets with heat-resistant polystyrenes or heat-resistant rubber-modified compounds to reduce the glass content.

Applications: Tape reels, blower wheels, textile bobbins, housings, and military devices that have to withstand rough usage.

Impact-type polystyrenes

As indicated above, copolymerizing styrene with acrylonitrile helped overcome many of the disadvantages of general-purpose styrene. Such copolymers have higher heat distortion, improved impact strength, excellent weathering resistance, better chemical resistance, and higher flexural strength at elevated temperatures. Izod notched impact strengths were still under 1 ft. lb./in. of notch, however, and it was recognized that greater improvements were desirable.

Accordingly, a basically new principle in polymer chemistry was evolved by which blends of resin and rubber were produced which exhibited the hardness and high heat distortion of the resin and the toughness and low brittle point of the rubber.

In most instances, these so-called "styrene alloys" involved a blend of styrene acrylonitrile copolymer resins with butadiene acrylonitrile rubbers. (To be considered a plastic, the resin ratio has to be over 60 percent.) Originally introduced in 1946 in the form of sheet stock, the materials are now commonly known as ABS polymer blends (acrylonitrile-butadiene-styrene). Between 1949 and 1955, more than 15 similar styrene alloys were introduced, based mainly on blends of polystyrene and/or styrene-butadiene copolymers of varying ratios. A number of variations of such alloys are, of course, possible since two ratios exist—styrene to butadiene and polystyrene to styrene-butadiene copolymer.

Also in 1949, a new series of molding powders was developed based on the same type of copolymer blend of styrene-acrylonitrile and butadiene-acrylonitrile that went into the sheet stock developed earlier. These new powders combined good physical properties with adequate flow at molding temperatures. Again, a wide range of physical and chemical properties is possible by adjusting the proportion of styrene-to-acrylonitrile in the resins and of butadiene-to-acrylonitrile in the rubber, as well as by varying the ratio of resin-to-rubber in the final alloy blend. Another combination of butadiene, styrene, and acrylonitrile, reported to be a "homogeneous" composition was introduced in 1953.

Manufacture

Polymerization of styrene, or copolymerization with a variety of other monomers including butadiene and acrylonitrile, may be accomplished by bulk, suspension, emulsion, and solution polymerization techniques.

Recent developments in techniques such as series, graft, and block polymerization are regarded as major advances in the art. Styrene alloys produced by use of these techniques reportedly offer greater ease in processability and relatively high impact strengths at low temperatures (—40° F.).

In the production of styrene alloys, latex blending and Banbury-mill mixing are used with equal success. Latex blending, as the name implies, involves the blending of polymer or copolymer latices. Coflocculation of the latices by the addition of sulfuric, lactic, or formic acid, or other flocculating agents results in a resinous crumb which is filtered and washed to remove soluble residue. When dried, this masterbatch may be compounded with other ingredients by Banbury, mill, extruder, or other types of mixers.

Properties

Basically, all the materials in this category are characterized by improved shock resistance and increased elongation, while still retaining good electrical and mechanical properties. By varying the resin/rubber ratio, of course, certain properties can be intensified, but sometimes at the sacrifice of others. For example, while the impact strength may be raised, it may be accompanied by a slight reduction in heat resistance, hardness, electrical properties, and some of the other strength properties. In addition, the blends cannot be produced with a high degree of transparency, although they are available in a wide range of both translucent and opaque colors.

Because of this variation in properties, the impact-type polystyrenes are generally subdivided into three general classes—medium-impact, high-impact, and super-impact, with increasing shock resistance or toughness shown in each classification. As with normal polystyrenes, impact materials are available with various combinations of flow and set characteristics suitable for optimum molding of parts according to wall thickness.

The styrene alloys are supplied in the form of pellets or granules for injection molding and in slabs or powder suitable for compression molding, extrusion, or calendering to sheets or film for laminating onto continuous reinforcing substrates.

Typical properties of the impact-type materials are listed in Table I, p. 169.

Applications: Molded parts include pipe fittings, wheels, helmets, valve parts, golf club heads, refrigerator parts, bobbins, radio cabinets, electric fan blades, toys, housewares, battery cases, and appliances. Extruded pipe is very popular in a number of important applications. Sheeting is used in industrial duct work, automobile head liners and kick plates, typewriter cases, refrigerator door liners, tote boxes, trays, and a variety of functional and/or decorative housings.

Oriented polystyrene

When stretched in the orientation temperature range while cooling, polystyrene develops increased strength up to threefold in the direction of stretch. Unidirectionally-oriented polystyrene and chemical resistant copolymer filaments are widely used as bristles for brooms and dusters as well as scrub brushes, utility brushes, and even inexpensive tooth brushes. When dry, the static charges developed by the brushing operation assist in causing lint and dust to adhere to the bristles. The adhesion, however, is not so strong that particles cannot be readily shaken or rinsed off.

Biaxially oriented polystyrene film is produced by stretching the plastic simultaneously laterally and longitudinally, while it is in the orienting temperature range. The film can be as thin as 0.005 in., used chiefly for electrical capacitors. Film of 0.001-in. thickness is used for laminating to impact-type polystyrene sheet to retain gloss after vacuum forming. Oriented polystyrene of 0.015-in. thickness is used to form venetian blind slats. Intermediate thicknesses are finding wide application in the packaging and luminous ceilings fields, as well as in coaxial cable spacer wrap. A biaxially oriented styrene-acrylonitrile copolymer film for greenhouse construction, storm windows, and similar outdoor applications is also available.

Polystyrene foams

Polystyrene foams are available in two types—free-flowing granules which are expanded in place, and logs or planks from which shapes are machined. Both types of foam are available at densities below 2.0 lb./cu. foot. Both exhibit very low water vapor transmission, low water absorption, low thermal conductivity, and good structural strength. Expanded polystyrene may be bonded to itself as well as to metals, glass, wood, and other solids. Polystyrene foam can be shaped as desired by common machining operations such as sawing.

References

Consult the Subject Index for additional information on styrene polymers and copolymers. For specific information on injection molding see p. 594. See also the Adhesives, Coatings, Films, Foamed Plastics, and Plastics Properties Charts for information on properties and trade designations. For sources of styrenes, see the Directory Index, p. 1078.

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Vinyl polymers and copolymers

By J. R. Bukey*

It was during World War II that the tremendous potential of the versatile vinyls was first realized. Since 1945 the growth pattern of these polymers has been phenomenal, increasing more than 1000% to sales of about 790 million lb. of resin in 1958. This rapid growth has been due to improvements made in quality and types of resins; the discovery of new and better plasticizers, stabilizers, and other compounding ingredients; improved and new processing techniques; and decrease in raw material prices permitting application in many new fields.

Polymerization

By definition, polymerization is a chemical reaction involving a successive addition of a large number of relatively small molecules (monomers) to form a final chemical compound or polymer (Fig. 1, below).

Vinyl chloride polymerizes rapidly under a variety of conditions. Polymerization may take place with the aid of heat, light, pressure, and catalysis, or any combinations of these. By varying polymerization conditions, a wide variety of resins can be obtained, including those which have controlled particle size and shape, chemical inertness, heat and light resistance, good electrical properties, and superior ability to absorb solvents and plasticizers. The type of polymerization used may depend upon specific techniques developed, properties required, and economics. The four commercial methods in use are described below.

Bulk polymerization: Monomer and a catalyst, such as an organic peroxide, are brought together and, as polymer is formed, it becomes insoluble in its monomer. When polymerization is completed, the polymer is separated, in fluffy form, from its monomer by filtering, flashing, or centrifuging. The resulting resins, freed from ionic impurities, have good electrical properties and their physical characteristics are such as to enable them to readily absorb plasticizer.

This method is not considered the best for a large-scale production, because the polymer obtained is in large masses, which cannot be easily disintegrated and processed. In addition, the heat of polymerization may lead to an uncontrollable reaction and loss of control of molecular weight. Thermal degradation, loss of HCl, and discoloration of the polymer also occurs to some degree.

Emulsion polymerization: This development is an outgrowth of research on synthetic rubbers. Vinyl chloride monomer is dispersed in water containing a small amount of an emulsifying agent such as sodium stearate, and a water-soluble initiator capable of producing free radicals such as potassium persulphate. Buffering agents may be added to control the pH. Among suitable catalysts that may be used are alkali metal persulphates, ammonium persulphate, and hydrogen peroxide. An activated system may be used (catalyst activated by a reducing agent) such as ammonium persulphate with sodium hydrosulphite and hydrogen peroxide. The main advantage of the latter system is that it permits faster rates of polymerization at lower temperatures because of a more rapid formation of free radicals.

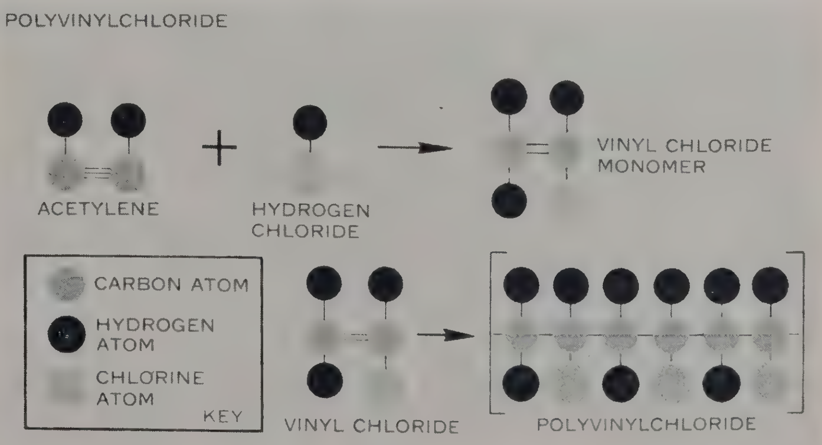
The colloidal emulsion of the polymer is then precipitated, washed, and dried, or dried directly by evaporation of water.

Most of the resin produced during World War II in Germany was made by this method. Emulsion polymerization is very practical, since it is possible to produce uniform polymers at high yields. In addition, the resulting polymer is in latex form which can be handled easily for the manufacture of many products.

While resins produced by this system usually are of small particle size and highly absorptive, they tend to carry ionic impurities which result in products with lower electrical properties.

Solution polymerization: Many media are solvents for monomer, but not for polymer, and in this process, both monomer and catalyst are dissolved in a suitable solvent. The resulting resins are relatively homogeneous and contain very little low-molecular-

FIG. 1: Formation of vinyl chloride monomer and polymerization to PVC



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[*] Mgr., Sales-Service, Firestone Plastics Co., Pottstown, Pa.
Recent Developments and References were prepared by the editors.

weight polymer of inferior physical properties. They are also comparatively free of inorganic contaminants which are difficult to remove from the emulsion polymers. This method is more adaptable for copolymer polymerization, because the solubility of polyvinyl chloride is relatively poor.

Suspension polymerization: This method can be brought to completion in droplets suspended in water with little local rise in temperature, and a suspension polymerization can be viewed as a colloidal dispersion of a bulk polymerization in an inert continuous phase. In large bulk or solution polymerization, local accelerated reactions occur, which are directly related to the poor heat transfer through the monomer-polymer slurry; therefore, bulk reactions cannot normally be carried further than 50% before the polymer must be removed. Technically, however, suspension polymerization of vinyl chloride is more difficult to carry out than emulsion polymerization of vinyl chloride.

In this type of polymerization, liquid vinyl chloride monomer containing a catalyst is dispersed under pressure, in water, in the presence of a stabilizing colloid, and maintained at reacting conditions until an economical conversion is reached. High purity water must be used in the reaction.

The suspension may be easily separated from the aqueous phase by filtering or centrifuging. Granulating agents and catalysts can be varied to give a wide range of polymers which plasticize readily and have improved heat stability and electrical insulating properties. Generally, molecular weight is controlled by temperature; the higher the temperature, the lower the molecular weight.

Suspension polymerization is also known as *granular* or *pearl* polymerization. The size of the polymer particles obtained depends upon the degree of agitation and can often be controlled by the use of various recipe additives. In general, the particles are coarser than those which are obtained when the emulsion system is the one used.

VINYL CHLORIDE POLYMERS AND COPOLYMERS

The vinyl chloride polymers and copolymers are made with a wide range of properties by controlling polymerization conditions. They are white powdery materials ranging in particle size from 1 to 300 microns. Under heat and pressure, they will fuse when compounded with stabilizers and plasticizers such as high boiling liquid esters, soft resins or elastomers, lubricants, and colorants. These compounds are easily converted into products of varying shapes and flexibility, ranging from soft flexible film to rigid sheet; they also can be fabricated into items of varying color, translucency, and opacity. Inherent advantages of toughness, excellent abrasion resistance, and resistance to acids, alkalies, alcohols, oils, fats, and waxes are also present.

The properties of nonextractability, fire retardancy, and water and moisture resistance are inherent in these resins and can be preserved and enhanced with proper choice of compounding ingredients.

Processing of vinyl polymers may be divided into two principal classes:

1) Where formation and physical property development are derived concurrently and processing heat is derived from external sources and mechanical working, as in calendering, extrusion, and molding. 2) Where solvents or dispersants are used to carry polymer and modifying ingredients into final form, with a) dispersant an integral part of the compound as in plastisols, or b) carrier or dispersants to be evaporated, as in solvent solutions or water dispersions.

General-purpose polyvinyl chloride

Resins suitable for calendering, extrusion, and molding are included in this group, which embraces a very large field, particularly in calendered products. General-purpose resin particles are usually designed to be either popcorn-like in shape, or round marble-like spheres, depending upon specific process handling and formulation. Particle size is comparatively large, ranging from about 40 to 250 microns, with an average of about 75 microns.

In calendering, it is often desired that the final compound show a fluffy dry appearance after the addition of comparatively high percentages of plasticizer at room temperature. Resins with particle size distribution in the lower range, large specific surface area, and low bulk density serve this purpose best. Such resins may be categorized as *ad*sorptive.

In extrusion and molding the more desirable resin is one that will *ab*sorb plasticizer easily under mild heating in the blender and thereafter flow freely. A larger particle size with high bulk density is preferred.

Particle surface and structure are important factors in controlling dryness and flowability. Generally, size is controlled by the type of polymerization or by mechanical means during polymerization. Particle shape or surface, and internal structure are usually controlled by recipe and technique.

In choosing the proper resin for a given end-use, physical properties, processing temperature available, mixing techniques, specific process, and thickness and shape of the finished material are all important considerations. Resins with a higher relative viscosity will usually result in higher strength properties and will generally require higher processing temperatures. Heavier calendered thicknesses or larger extruded or molded sections may process easier, at a slight sacrifice of properties, by selecting a resin, or combination of resins, in a lower relative viscosity class.

Dispersion resins

Many new types of *dispersion* and *blending resins* have appeared in the last few months. Homopolymers of vinyl chloride have appeared as "blending resins," used to lower and otherwise alter the paste viscosity characteristics of a dispersion resin system. The new homopolymers have superior heat stability to the earlier copolymer blending resins. Figures 2 and 3, p. 174, show the

Development of a non-staining finish has been announced for a laminate-quality vinyl sheeting *(Colovin,* Columbus Coated Fabrics) . . . the sheeting can be laminated to steel, aluminum, and other metals. Although developed primarily for use with white vinyl, the formulation is also available in any other color, multicolored combinations, and various textured effects.

Vinyl acetate-vinyl stearate copolymer emulsions (*Flexbond,* Colton Chemical Co., Div. of Air Reduction Co.) yield films with grease and water resistance, nontoxicity, permanent flexibility, heat sealability, excellent adhesion, transparency . . . used in paper coatings, food packaging film, textile and leather finishes and coatings, adhesives, and paints.

Tougher and lighter extruded polyvinyl chloride tubing (*Resinite EP-145,* Borden Chemical Co., Resinite Dept.) . . . for jacketing coaxial, umbilical, and other cables . . . is an improved equivalent of Specification MIL-R-6855, Class II, Grade 60, synthetic rubber. Does not deteriorate from exposure and remains flexible at temperatures below —100° F. . . . is flame-resistant and self-extinguishing.

Recently added to the Underwriters' Laboratories' interchangeability list for electrical applications are a number of polyvinyl chloride resins from various manufacturers. Among these are four approved resins for extrusion, calendering, and molding (*PVC 1250-E; 1225-E; 1200-E;* and *1185-E,* Escambia) . . . a uniform, gel-free resin (*Trulon 500,* Thompson Chemical Co.), giving high rates of extrusion with a glossy, smooth surface . . . a dry blending vinyl chloride resin *(Kohinor 652,* Eleonora Chemical Div., The Pantasote Co.) for the calendering and extrusion field . . . UL also announced approval of *Kohinor W-200* for types T, TW, 60° C., and 80° C. insulation.

Fungicidal and fungistatic additive (*Ottacide P,* Ottawa Chemical Co.) inhibits fungus growth in semirigid and rigid polyvinyl chloride compounds and copolymers.

Cold-water-soluble polyvinyl alcohol (*Vinol* CWS, Colton Chemical Co., Div. of Air Reduction Co., Inc.) has good adhesive properties, clarity, and binding abilities . . . forms permanently flexible films.

Polyvinyl acetate emulsion (*Gelva Emulsion TS*-66, Shawinigan Resins Corp.) . . . specifically designed as vehicle in gloss and semigloss water-based paints . . . solves main problems of water-based gloss paint—lasting hardness of the paint film and durability of gloss even after frequent washings.

Vinyl-coated *(Geon,* Goodrich, by Sherwin-Williams) aluminum house siding (Hastings Aluminum Products) is expected to maintain its finish for many years . . . can be washed down with a garden hose. Both sides are coated before application . . . the metal can be formed, bent, or otherwise handled.

Vinyl wrinkle finish (Union Carbide Plastics Co., Div. of Union Carbide Corp.) is based on plastisols or organosols . . . the principal factor is a polymerizable plasticizer (*Monomer MG-1*).

Vinyl plastisol containing powdered lead (*Coustifab,* Cordo Chemical Co.) treats cotton or fibrous glass fabric so it will absorb low-frequency engine sounds in jet airliners. . . . material can also be used as a sound dampener for machinery.

Plastisol-coated steel (U.S. Steel) will withstand elongation of 30% with no effect on the coating . . . will take 160° F. on a continuous basis, 212° F. for two days . . . coating can be embossed in any desired color.

An extruded, plasticized polyvinyl chloride film (*Vitafilm F,* Goodyear Tire & Rubber Co.) . . . approved for food packaging by the Pure Food and Drug Administration . . . can be used either in straight or over-wrap applications . . . readily laminates to paper, film, or foil.

System for bonding vinyl sheet or plastisol to metal involves a new synthetic cement (*A-978-B,* B. F. Goodrich) and a specially formulated plastisol . . . has excellent adhesive qualities . . . laminate can be stretched 35% without weakening the bond.

Polyvinyl fluoride film (*Type R,* Du Pont) is available in developmental quantities . . . suggested for outdoor and industrial applications, such as agricultural glazing, inflatable structures, electrical parts, surfacing for laminates . . . usable in products requiring resistance to temperatures of from —100 to 250° F.

Special thermosetting adhesive (*No. 69X-1487,* Stanley Chemical Co.) is applied with heat and pressure . . . is said to withstand drawing pressures exceeding the fracture point of the metal itself.

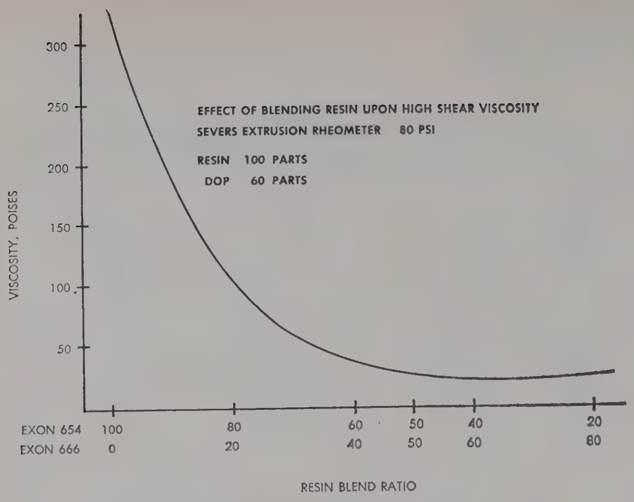


FIG. 2: Viscosity depressing effect of blending resin

viscosity depressing effects of such a resin at high and low shear rates. It should be noted that viscosity, when used to describe plastisols, refers to apparent paste viscosity. This is used to differentiate it from relative viscosity, which is used to measure molecular weight.

Advances in the technology of resin production have enabled the resin manufacturer to produce and select resins with many of the rheological properties which fit into specific applications. The resin manufacturer can now select "high yield" resins for dipping operations or "low yield" resins having low viscosity at high shear rates for roller coating upon flat surfaces. The term "high yield" means that a paste has a higher apparent viscosity at lower ranges (at rest or under its own weight) than at high shear ranges (mixing or spreading). The solvent—i.e., plasticizer—resistance of the resin can also be varied. Custom compounders who ship pastes great distances over extended periods of time require a resin with excellent paste viscosity stability. Roller coating operations, etc. where speed of curing is essential, will require a resin which solvates rapidly in order that maximum physical properties may be developed rapidly.

Dispersions may be divided into three general classifications:

1) *Plastisols,* which usually contain plasticizers, stabilizers, fillers, color pigments, surfactants, etc.

2) *Organosols,* which differ from plastisols in that they contain a nonaqueous, volatile liquid phase. The liquid components of organosols are usually classified as dispersants or diluents. Dispersants aid in wetting and dispersing the resin. They are usually polar compounds and have a strong attraction for the resin. Examples of dispersants include esters, glycol ethers, ketones, and plasticizers. Diluents are used to lower viscosity of the liquid phase, and in general they tend also to reduce the per pound cost of the compound. They may modify the wetting and swelling characteristics of the dispersants. Examples of diluents are the aromatic and aliphatic hydrocarbons. Diluents must have a minimum solvating action on the resin to be effective. For this reason the aliphatic hydrocarbons are usually preferred over the aromatics. Figure 4, p. 175 illustrates a typical diluent-dispersant-viscosity curve.

3) *Modified plastisols,* which contain additional ingredients such as blowing agents to produce foams and gelling agents to produce plastigels. One of the newest entries into the field is the rigid plastisols. By utilizing blending resins and minimizing plasticizer loading, very hard coated or molded products can be obtained.

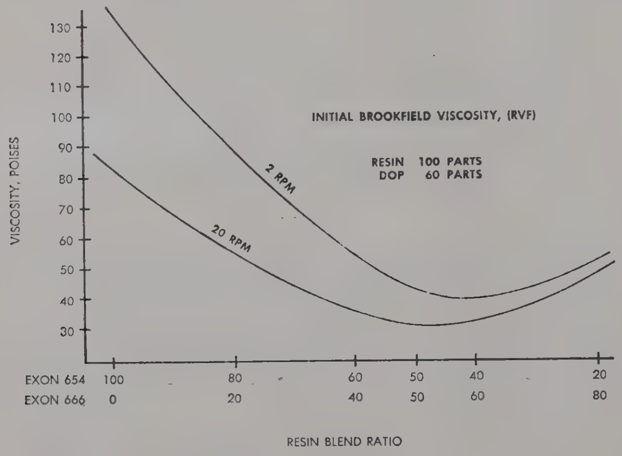
Latex

Latex is a colloidal suspension of vinyl polymer or copolymer resin particles in water, usually with a total solids content of 45 to 55% and is produced by emulsion polymerization. The resin particles are true colloids of spherical shape.

Since all latex compounding is done either by adding water solubles or colloidal suspensions to the latex, a number of modifications of the continuous phase of the latex are often made. Protective colloids, thickeners, emulsified plasticizers, and colloided pigments are often present. To achieve stable balance in such a complex system often requires the addition of an auxiliary emulsifier or stabilizer in addition to the one used during the polymerization process. Due to the particular nature of each of these complex systems, the choice of these emulsifiers is extremely specific and each system must be studied separately before the proper choice can be made.

A typical latex contains about 50% solids with a Brookfield viscosity of 20 to 150 cps. The rela-

FIG. 3: Viscosity depression with blends. See text, also Fig. 2



tive viscosity of the resin may be in the 2.3 to 2.6 range.

Four general types of latices are available: 1) Dispersions of vinyl polymers, which require the addition of a plasticizer emulsion before processing; 2) dispersions of polyvinyl chloride copolymers or internally plasticized polymers, which can form films at room temperature; 3) dispersions of vinyl chloride polymers which have been specially modified to form films at room temperatures; and 4) dispersions of vinyl polymers which are preplasticized and will form films at processing temperatures without additional compounding.

These latices are designed primarily for coating, impregnation, and saturation of fibrous materials such as fabric, paper, non-woven constructions, and leather. Such treatments provide products with superior abrasion resistance and physical properties, excellent washability, and flame and chemical resistance.

Formulations of latices can be compounded for such specific applications as: 1) fabric precoats for subsequent application of plastisol, organosol, or vinyl solution; 2) carriers and binders for phosphates, antimony oxide, and chlorinated paraffins for flame resistant saturants; 3) heat sealing coats for lamination of paper and fabric; 4) abrasion resistant coats over substrates such as printed paper, vinyl sheeting, and cloth; and 5) water based paints. The versatility of the vinyl latices also includes their adaptability to standard application methods: air blade, roller, brush, spray gun, doctor knives, and orifice dies are successfully used. Other specialized methods such as coagulant dipping, slush coating, and immersion impregnating are used where heavier applications are required.

Other vinyl latices which should be included at this point are not commonly referred to as vinyls, but the apparent inconsistency is only by definition. The most common of these "other vinyls" are *vinyl benzene, vinyl cyanide,* and *vinyl pyridine,* all of which are involved in polymerization with butadiene to form copolymers or with other monomers to form even more complicated poly-polymers of tremendous interest to industry.

The common name for vinyl benzene is stryene and the most familiar latex product is GR-S (synthetic rubber) latex. Products from a copolymerization of styrene and butadiene include many such common items as foamed latex products, the revolutionary "latex paints," and many fiber products reinforced through impregnation or coating.

Dried latex products, normally called rubber or resin depending on the monomer type and composition, include such familiar end products as tires, shoe soling, adhesives, and molded goods such as battery cases and toys.

Acrylonitrile, which can also be considered *vinyl cyanide,* has found widespread utility when copolymerized with budadiene to form oil-resistant rubbery products used in gaskets, closures, tubing, and stripping where resistance to solvents is critical. Many low-grade or split-grain leather articles are beautified and improved through the versatility of Butaprene N latex.

Vinyl pyridine, when properly polymerized, compounded, and applied, increases adhesion of rubber to rayon and nylon and provides that extra safety factor in tires by preventing ply separation and subsequent tire failure.

All of these materials when properly combined with butadiene provide molecular structures entirely suitable for cross-linking with sulfur to increase strength and durability. The normal compounding techniques for rubber apply only with respect to cross-linking or curing, since the addition of fillers or so-called rubber reinforcing agents only weaken the end product.

Soluble copolymers

A number of vinyl copolymers have been developed for application in diversified lacquer-type coatings. These resins are designed with varying degrees of solubility so that a resin may be selected for specific application requirements. However, the solubility of long-chain organic polymers cannot be altered without affecting the physical properties. Therefore, performance characteristics must be carefully considered in the design of a polymer.

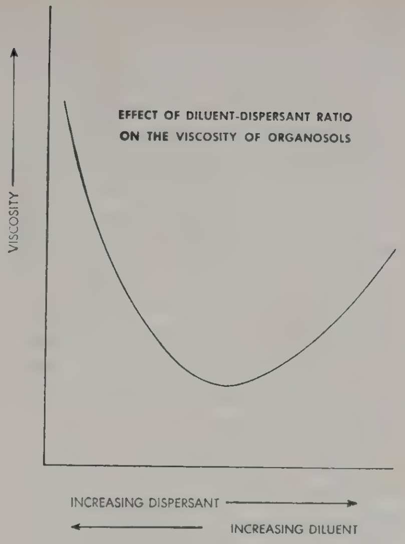


FIG. 4: Organosol viscosity vs depressants and diluants

The polyvinyl chloride polymers are not sufficiently soluble for lacquer coating formulations. To obtain increased solubility, vinyl chloride is copolymerized with a number of other monomers, such as vinyl esters or the maleates or vinylidene chloride to modify the polymer molecule.

Typical resins for solution applications range from about 1.35 to 1.95 in relative viscosity. (Note: The viscosity of copolymer resins is definitive only when comparing those polymers having the same type and ratio of monomers in their make-up.) Some resins are designed for metal adhesion, while others are designed as strip coatings. Transparency, as well as chemical, electrical, and abrasion resistance, are additional outstanding properties.

Polyvinyl chloride-acetate

Copolymerization of vinyl chloride with vinyl acetate results in a material which retains the toughness and chemical resistance of polyvinyl chloride and has increased flexibility. These copolymers are odorless, tasteless, water-resistant, and self-extinguishing; they possess good dielectric properties and a low order of toxicity. The vinyl chloride content in these copolymers varies from 85 to 97 percent. Both solution and suspension polymerization techniques are being used.

Also like their parent polymers, vinyl chloride-acetate resins are modified by the addition of plasticizers, heat stabilizers, pigments, and fillers to obtain a variety of products. They are supplied as sheets, rods, tubes, granules, powders, and dispersions, and may be fabricated by standard molding, extrusion, calendering, casting, as well as the various coating techniques.

Vinyl chloride-acetate copolymers have been particularly useful in the form of unplasticized sheets which are produced commercially with calendered, matte, or planished finish in a variety of thicknesses, colors, and degrees of transparency. One of the fastest-growing applications for these resins is in skin-packaging with cast film.

Vinyl chloride-acetate elastomeric materials are used for upholstery, handbags, luggage, gaskets, and packaging applications and are extruded into rods or tubes for electrical jacketing and insulation.

Compound grades and types

The vinyl chloride polymer and copolymer plastics are available as nonrigid and rigid materials. The nonrigid materials, often referred to as elastomeric vinyl plastics, have been divided by the American Society for Testing Materials into two types in tentative specification A.S.T.M. D-1432-56T. General purpose compounds, Type I, are classified under 16 grades, depending upon their functional properties and anticipated service conditions. Electrical insulation general-purpose compounds, Type II, are classified under 6 grades, depending upon the type of insulation required and anticipated service conditions they will undergo.

The rigid materials, often referred to as rigid vinyl or unplasticized polyvinyl chloride, have been divided by the Thermoplastic Structures Div. of S.P.I. into two types, and are classified in the Commercial Standard Number CS-201-55 for Rigid Polyvinyl Chloride Sheets. Type I has normal impact strength and Type II has been modified to increase the impact properties required by many applications.

Application in industry

Nonrigid (flexible) vinyls are used widely as insulating and jacketing materials on electrical wire and cables. Their excellent dielectric properties and resistance to oil and water make them especially suitable for this purpose. Their versatility is demonstrated by their acceptance for a wide variety of extruded items such as garden hose, refrigerator gaskets, shoe welting, storm window gaskets, medical tubing, automotive gaskets, and electrical sleeving.

Thin films of vinyl plastic are fabricated into protective garments, rainwear, aprons, shower curtains, and baby pants, as well as such items as garment bags, hospital sheeting, and draperies. Heavy gage sheets are widely used as upholstery for furniture and in accessories such as handbags and belts.

Vinyl sheeting is laminated to fabric backing to produce coated fabrics for automotive upholstery and outer wearing apparel.

A relatively new technique using heat, pressure, and special adhesives is employed to laminate vinyl sheeting to sheet metal such as steel, aluminum, and magnesium. This product can be formed into radio cabinets, luggage, paneling, business machine housings, automotive trim, and many other items.

The excellent durability and abrasion resistance of vinyl plastics has made them one of the major raw materials of the floor covering industry, amounting to 90 million lb. in 1957 or about 13% of the entire polyvinyl chloride market.

The vinyl plastics are especially useful in molding tough, durable items such as vacuum sweeper bumpers, gaskets and hose, luggage binding, cord plug sets, automotive parts, and toys.

Expanded vinyl: The nonrigid and semirigid vinyl plastics are being rapidly accepted in expanded items such as comfort padding and fishing floats. A comparatively recent development is the use of vinyl pastes in a foaming process for the commercial preparation of low-density expanded polyvinyl chloride products in continuous slab form. (See also the section on Foamed Vinyls, p. 286.)

Functional and decorative rigid shapes are being used to replace light weight metals in industrial applications. Rigid vinyl sheets, usually self-extinguishing, present a minimum fire hazard and are of interest to the building industry for such applications as decorative paneling and luminous ceilings. They are also particularly suited for the vacuum forming industry and are used to make such items as packages, advertising displays, and electrotype molds. Phonograph records, molded from rigid vinyl copolymer plastics have high fidelity, low surface noise, and are practically unbreakable.

POLYVINYL ACETATE

Prepared by the polymerization of vinyl acetate in the presence of a catalyst in a manner similar to vinyl chloride polymerization, polyvinyl acetate is available either as a granular resin or a dispersion in water. These resins are readily soluble in ketones, esters, aromatic hydrocarbons, and chlorinated hydrocarbons. They are insoluble in water, aliphatic chlorinated hydrocarbons, glycols, higher alcohols, oils, and fats. A large portion of these resins goes into making adhesives and coatings. Properly formulated, they can be applied by brushing, molding, calendering, dipping, and roll coating. Adhesive applications of polyvinyl acetate include the bonding of cellophane, paper, cloth, mica, ceramics, metal, stone, wood, leather, glass, and cellulose ester sheets and film. Commercially, they are used as binders for metallic inks and for applications such as textile sizing.

POLYVINYL ALCOHOL

Since vinyl alcohol does not exist in monomeric form, vinyl alcohol resins cannot be prepared by direct polymerization but are produced by the hydrolysis of polyvinyl acetate, using an acid or alkali catalyst. Acid catalysis is preferred since it has been found that alkaline hydrolysis gives an undesirable color to the product. The degree of hydrolysis is a governing factor in the properties of the end products. These resins are generally soluble in water.

Polyvinyl alcohol resins are processed by molding, extrusion, and solution coating. They produce tough, flexible products that are impervious to gases and water-insoluble solvents, such as aromatic and aliphatic hydrocarbons, chlorinated hydrocarbons, and animal and vegetable oils.

POLYVINYL ACETALS

These resins differ from polymers of vinyl chloride and vinyl acetate in that they do not result from the additional polymerization of monomer. Instead, polyvinyl acetals are produced from a condensation of polyvinyl alcohol with an aldehyde. A polyvinyl acetate of desired molecular weight is first dissolved in a solvent such as methanol and then hydrolyzed to polyvinyl alcohol. This hydrolysis product is reacted with an aldehyde in the presence of moderate heat and a suitable catalyst, such as sulfuric or hydrochloric acid, to yield a typical cyclic acetal structure. There are three main groups of polyvinyl acetals—polyvinyl acetal itself, made with acetaldehyde; polyvinyl butyral; and polyvinyl formal. All three have outstanding adhesive qualities.

Polyvinyl acetal is used most often in adhesives, impregnating coatings, photographic film, sheets, rods, and tubes. Because this resin has a slight yellowish cast, its usefulness is limited to applications in which color is not a decisive factor. Polyvinyl acetal is processed by casting, coating, extrusion, and molding.

Polyvinyl butyral: Because of its high degree of clarity, even under adverse conditions of moisture, heat, and cold, this resin is best known for its use as an elastic sheeting for safety-glass interlayers. However, it also performs in an outstanding fashion as a base for wash primers or metal conditioners. Applied in an extremely thin film, this conditioner provides an excellent adhesive bond for subsequent coats as well as a temporary resistance to corrosion. Phenolic, alkyd, and oleoresinous paints adhere to the wash primer, usually with improved performance. This primer permits an all-vinyl system to be used in marine and industrial applications. For this application, and for molding compounds, vinyl butyral resins are supplied as solution-grade granules. They can also be cross-linked by phenol-formaldehyde and urea-formaldehyde resins to produce coatings and adhesives for bonding phenolics, rubber, cork, asbestos, board, wood, glass, ceramics, cloth, paper, and metals.

Polyvinyl formal: Used chiefly in wire coatings in combination with cresylic phenolics or other impregnants, these resins can also be molded, extruded, or cast. Like polyvinyl butyral, this resin resists alkalies, greases, oils and water. However, it is not as compatible with other resins as is polyvinyl butyral.

POLYVINYLIDENE CHLORIDE

When vinylidene chloride is polymerized alone or copolymerized with other monomers, a series of resins is produced, ranging from flexible, moderately soluble materials with a softening point of about 160° F., to hard, tough products with a softening point of 335° F. or more. These resins are characterized by extremely low water-vapor transmission and exceptional oil, grease, and chemical resistance. These properties are due, at least in part, to the high crystallinity of the resin.

The basic resins are nonflammable and are soluble only in cyclic ethers and ketones. The insolubility of some vinylidene chloride resins allows them to be used in many applications requiring exceptional chemical resistance. These polymers are compatible with very few other resins and plasticizers; however, they can be modified for specific applications.

Polyvinylidene chloride resins have been found particularly well-suited for injection molding and extrusion. Extruded and oriented, they are used in weaving upholstery fabrics, draperies, and weather-resistant screening, as well as for rigid pipe and fittings. In film form, polyvinylidene chloride resins are used for a variety of heat-sealing packaging applications.

Vinylidene chloride has often been copolymerized with vinyl chloride. Because of the greater solubility of this copolymer, these resins are more valuable in the solution coating field than is either homopolymer. Copolymers of vinylidene chloride-vinyl chloride can be put to good use in metal and fabric coating and in casting or calendering films. These films and coated materials can be easily heat-sealed at temperatures ranging from 275 to 320° F. The copolymers can also be extruded to produce flexible tubing and electrical insulation for a variety of different applications. Vinylidene chloride copolymerized with acrylonitrile also possesses interesting advantages for specialized end uses.

References

Consult the Subject Index for additional information concerning vinyl polymers and copolymers. For specific information on injection molding see p. 594; extrusion, see p. 656. See the Adhesives, Coatings, Films, Foamed Plastics, and Plastics Properties Charts for information on properties and trade designations. For sources of vinyls, see Directory Index, p. 1078.

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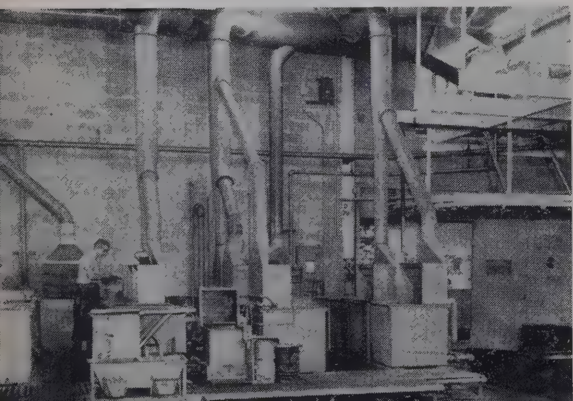
"Hot subject: heat sealing," MODERN PLASTICS *35*, 85 (Apr. 1958).

GROWING MARKETS for rigid vinyl: Lightweight luggage thermoformed from rigid vinyl sheet is both attractive and long wearing . . .

. . . window frames extruded of rigid vinyl (above), as well as sashes and sidings, are first being investigated . . .

. . . bubble packages (above) are clear and tough, can be formed on relatively short cycles . . . but the greatest potential for rigid vinyl is still in piping, such as that used below in an industrial plating department where corrosion resistance plus strength is required. (Top three photos, Goodrich; bottom photo, Tube Turns Plastics)



Rigid vinyls

By Jean F. Malone*, George A. Fowles†, William E. Manring‡

Only ten years ago, commercial interest in unplasticized (rigid) polyvinyl chloride was negligible. Yet by 1957 the consumption of rigid PVC for pipe and profile extrusions was at an annual rate of about 10 million lb. of material, and it is estimated that this will reach 60 or 70 million lb. by the mid '60's.

Also in the rigid vinyl field is a copolymer of polyvinyl chloride, developed somewhat earlier than straight PVC; the two materials are quite different in composition and should not be confused with each other in the following discussion. Physical properties of the copolymer and of the two commercially available types of unplasticized PVC are given in Table I, p. 180.

The chemical inertness of rigid vinyls is often their prime recommendation. They can withstand many acids and alkalies, metallic and ammonium salts, and organic media such as alcohol and aliphatic hydrocarbons. They also show good tensile strength, abrasion resistance, resistance to heat distortion, and excellent electrical properties.

Types available

Unplasticized PVC compounds consist essentially of a polyvinyl homopolymer of high molecular weight, suitably compounded with stabilizer, lubricant, and pigment. The normal-impact formulation, usually referred to as Type I, is compounded to the minimum extent necessary to secure good processing. Type I rigid vinyl compounds show notched Izod impact values in the range of 0.75 ft.-lb., and are noted for their superior chemical resistance.

High-impact rigid vinyl, known as Type II, is modified during manufacture to increase impact resistance. The slight loss in chemical and other physical properties that results is of importance only in critical applications.

Processing

Although injection molding (see p. 594) and calendering are important methods of processing normal- and high-impact PVC, extrusion (see p. 656) consumes the largest volume and is very likely to increase its lead in the future.

The extrusion of pipe, for example, has progressed in quality and has become sufficiently standardized to permit accurate prediction of performance under specified conditions. Large cross-sections have become much less of a problem. A 14-in. pipe, for example, is now being produced as a commercial item. The surface is excellent, and roundness and wall thickness are maintained within very close tolerances.

Improvements have also been made in the design of dies for the extrusion of rigid PVC sheet. A new development is a flat die for producing ⅛ in. thick sheet 48 in. wide. Thicker sheets have been extruded from unplasticized vinyl but not in such wide width. Such sheets eliminate costly laminating of calendered sheeting to acquire the desired thickness and put rigid vinyls in a position to compete costwise with other plastics in this area.

Pipe

Most of the recent activity in rigid PVC extrusion has been in pipe, with normal-impact material going principally into the eastern market for processing industries (i.e., brewing, vinegar, chemical) and the high-impact type directed toward the western market for oil field, gas, and water piping and similar applications.

Petroleum and gas: Although

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*Product Engineer, Plastics Materials; †Manager, Plastics Materials Sales; ‡Sales Development Manager, New Products, B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio.

Recent Developments and References were prepared by the editors.

chemical and water service are probably larger applications at present, rigid vinyl pipe is expected to gain momentum rapidly in petroleum and gas service. Half a million lb. per year were used for such service in 1957 and 1958 and the growth rate indicates that from 6 to 8 million lb. will be used annually by 1962.

Rigid PVC pipe is expected to compete favorably with other plastics in oil fields for the disposal of brine and for crude oil transmission; it is immune to galvanic corrosion and highly resistant to both salt water and crude oil. In petroleum and gas service, rigid vinyl pipe is particularly useful where soil is corrosive and paraffin accumulation on pipe walls is a problem. Such pipe is best used at pressures under 75 p.s.i. and where pressure surges are not encountered.

The recent installation of 15,000 feet of rigid vinyl pipe by a public utility company in 2 p.s.i. gas service lines is probably the start of large-scale use of rigid vinyl for such lines. Part of this pipe was pulled through metal lines which had failed; the remainder was buried direct. Results with both methods have been good.

Irrigation and water service lines are now estimated to account for 15 to 20% of all rigid vinyl pipe produced. By 1962, it is predicted that somewhere around 7 million lb. will be used annually, with steady growth thereafter.

Rigid PVC pipe is replacing metal in many applications where light weight, economy of installation and anticorrosive properties are desirable. Utility companies are installing rigid PVC where they have to bring in their water supply from distant sources; underground sprinkling systems are employing rigid vinyl; Florida hotel swimming pool piping is being converted from metal to PVC to prevent salt water corrosion and one hotel uses PVC in its air conditioning water lines to prevent corrosion and also to save weight on top of the building; and rigid PVC pipe has been installed in a 15-mile irrigation system in an avocado grove in California, replacing metal pipe which corroded rapidly when buried in continuously moist soil.

A new variation in pipe is an extruded rigid vinyl liner 0.065 in. thick which is used inside a steel pipe. This is intended to prevent corrosion in high temperature and high pressure applications. The potential savings in maintenance that can be made from this combination is a big enough factor to consider a future in millions of feet.

Extruded shapes

There is a good possibility that eventually profile extrusions will account for more poundage than will pipe. An estimated 2 million lb. per year (as compared to practically nothing a few years ago) was used for extruded shapes and profiles in 1957-58. Five years from now this figure is expected to be 6 or 8 million. As work progresses, it is expected that improvements will be made in the resins themselves—their processing properties should improve as well as their resistance to such factors as temperature and sunlight.

Even in their present stage of development, rigid vinyl extrusions are finding important applications. Extruded vinyl conduits, which are being used for underground service by a power company, are easier to install than metal, have superior electrical properties, and are resistant to chemical fumes and liquids. The smooth interior will not corrode and will make it easy to pull wires through the conduit for years to come.

In other fields, extruded U-shaped channels serve as insulators for bare wires on overhead power lines and make it possible to install 3 to 12 wires close together where space is limited; PVC links on conveyor belts are not abraded by the constant friction of moving parts; and high-impact rigid vinyl moisture eliminator baffles for large industrial air conditioners are not affected by moisture-laden air and

pments...Recent Developments...Recen

The water supply company of Odense, Denmark, recently ordered nearly eight miles of 8-in. rigid polyvinyl chloride pipe . . . nominal working pressure, 85 p.s.i. . . . test pressure, 522 p.s.i. (Polyplex Danish-American Plastics Co., one of the suppliers). Biggest PVC pipe installation in England is said to be an effluent line . . . 12,000 ft. of 4-in. and 6-in. tubing (*Geon Hipact*).

Rigid unplasticized polyvinyl chloride, Schedule 40, is now specified by the City of Miami Beach's electrical code . . . for conduits in certain installations of electrical, signal, and telephone wiring where corrosion is a problem.

New method for molding unplasticized polyvinyl chloride and its copolymers (Union Carbide Plastics Co., a Div. of Union Carbide Corp.) . . . involves high-frequency preheating and plunger molding (see p. 631).

Heavy-walled rigid polyvinyl chloride pipe (Alpha Plastics, Inc.) . . . . U.S. Navy has ordered 50 miles for use in above-deck seawater washdown systems designed to protect ships and crews from radioactive fallout.

Three new formulations of rigid vinyl sheeting (Union Carbide Plastics Co., Div. of Union Carbide Corp.) have improved impact strength . . . *VCAB-3603* is designed for unusually high impact strength . . . *VCAB-3604* has superior light stability . . . *VCAB-3605* has high resistance to heat distortion.

their light weight eliminates the necessity for elaborate supporting structures.

Other applications for rigid PVC extrusions are runners for bowling ball return tracks; scuff-resistant moldings and strips for autos; tracks and thresholds for sliding doors; architectural moldings and edging for work counters; functional and trim strips for radios, air conditioners, etc.; and an extruded duct simplifies installation of switchboards, instrument panels, and electronic systems by permitting wire to be led out from the main channel through evenly spaced perforations.

A rigid vinyl window frame and sash are now in production. In other applications, window tracks and frames are lightweight and permit easy and soundless operation. These window tracks are particularly promising, with each window using 10 ft. of track. Some 1,000,000 new homes a year are prospects for this item. At least one manufacturer of storm doors and windows is making a complete vinyl frame and sash. Others are using rigid vinyl components.

Perhaps the greatest potential use for rigid PVC is for sidings on buildings, downspouts, gutters and even roofing. However, interesting as these applications may seem in terms of their tremendous potential in the building field, work has not progressed far enough to estimate their future.

TABLE I: Physical properties of rigid vinyls

	A.S.T.M. Method	*Rigid vinyl copolymer*	*Rigid PVC Type I*	*Rigid PVC Type II*
Specific gravity	792–47T	1.37-1.45	1.38	1.35
Tensile strength, p.s.i.	638-49T	7500	8500	6000
Flexural strength, p.s.i.	790-49T	12,000	13,500	12,000
Flexural modulus, 10^5 p.s.i.	790-49T	4.5-5.0	5.0	3.5
Izod impact, ft.-lb./in. of notch @ 72°F.	256-47T	0.5	0.8	15
Izod impact, ft.-lb./in. of notch @ —20°F.	256-47T	0.2	0.3	1
Thermal expansion 10^{-5}/°C.	696–47T	7	5	10
Heat distortion, °F. @ 66 p.s.i.	468-45T	—	165	160
Heat distortion, °F. @ 264 p.s.i.	648-45T	145	160	158
Rockwell hardness	785-48T	—	R110	R105
Moisture absorption, % in 24 hr.	570-42	0.08	0.05	0.10
Dielectric strength, short time, v./mil.	D149-44	425	1400	1100
Dielectric constant @ 10^6 cycles	D150-47	3.0	3.0-3.5	—
Ultra-violet resistance		Good	Good	Good
Heat formability		Good	Fair	Fair
Flammability, in./min.	D635	Self-extinguishing		
Thermal conductivity, 10^{-4} cal./cm.^{2}/sec./°C.		3.7	3.5	4.5

Copolymer sheet

Most of the rigid vinyl sheeting currently being consumed is calendered vinyl copolymer.

Relief maps, which were the first large-scale vacuum forming application, are made of unplasticized vinyl copolymer sheeting and now use thousands of pounds of resin a year. Toys and novelties also account for a large segment of this market.

There are scores of uses for printed and embossed vinyl copolymer sheet: credit cards, book bindings, wall coverings, advertising displays, playing cards, milk bottle caps, measuring instruments, templates, etc.

Building structures, such as partitions, are a good potential market, but so far haven't developed greatly because of competition from other materials.

There should be natural expansion in all of these applications with further development of extruded sheet, but particular growth may be expected in packaging laminates and lighting components. Lower cost should also encourage expansion into new markets such as refrigerator liners, housings, and luggage.

References

Consult the Subject Index for additional information on rigid vinyls.

For sources of rigid vinyls, see Directory Index, p. 1078.

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Naugatuck Plastics

RESIN GUIDE

1959–1960

KRALASTIC® RESIN-RUBBER COMPOUNDS (Thermoplastic)

VIBRIN® POLYESTER RESINS (Thermosetting)

MARVINOL® POLYVINYL CHLORIDE RESINS (Thermoplastic)

Naugatuck KRALASTIC

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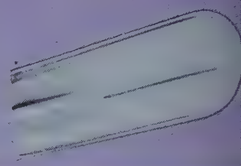
KRALASTIC molding and extruding compounds are unique combinations of thermoplastic resins and nitrile rubber. The result is an almost indestructible end product of exceptional strength, toughness and impact resistance.

Extruded as plastic pipe, Kralastic has proved phenomenally successful and durable in transporting salt water and sour crude in the oil fields; carrying natural gas, drinking water, corrosive chemicals, irrigating water; and as money-saving, quickly-installed electric conduit.

With the recently introduced Kralastic HTHT (high temperature, high tensile) and the dramatic new Kralastic MM, a compound so tough, so resistant to heat, staining and abrasion it rivals nylon, the Kralastics offer molders and users everywhere a combination of properties that is truly exceptional.

Consult us for experienced application advice, for information on independent test results, for whatever assistance you may require.

Helmets of practically ev
description are lightweig
colorful, easily molded, tou
and impact resistant as o
Kralastic can make them.

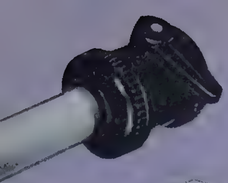


PROPERTY	UNITS	ASTM TEST METHOD	KRALASTIC B	KRALASTIC F
PHYSICAL				
Specific Gravity (Natural Color)*			1.06	1.04
Impact Strength (¼" Bar Sample)				
Izod Notched, 73°F.	ft. lbs./in. notch	D256-56	5-9	3-6
Izod Notched, 32°F.	"	"	1.8	1.5
Izod Notched, −40°F.	"	"	0.6	0.4
Charpy Unnotched, 73°F.	ft. lb./in.	"	35-58	28-42
Charpy Unnotched, 32°F.	"	"	35-50	40-45
Charpy Unnotched, 0°F.	"	"	35-50	21-26
Charpy Unnotched, −40°F.	"	"	8	6-8
Compressive Strength	psi	D695-54	6,400	5,800
Compressive Modulus	psi	D695-54	290,000	280,000
Flexural Strength	psi	D790-49T	8,000	7,500
Flexural Modulus	psi	D790-49T	260,000	250,000
Tensile Strength	psi	D638-52T	5,500	5,000
Hardness, Rockwell	R Scale	D785-51	96	92
Thermal Coefficient of Expansion	in./in./°F.	D696-44	0.000056	0.000056
Thermal Conductivity	B.T.U./hr./ft.^{2} per°F./in.	C177-45	1.7	2.0
	Cal/sec./cm^2/°C./cm		0.00060	0.00069
Specific Heat	B.T.U./lb./°F.		.37	.36
Deflection Temperature, 264 psi	°F.	D648-45T	187	185
Water Absorption, 24 hrs.	% Gained	D570-54T	0.3	0.2
Compression Ratio (Bulk Factor)		D392-38	1.8-2.0	1.8-2.0
Compression Molding				
Temperature	°F.		325-400	325-400
Pressure	psi		1000+	1000+
Injection Molding				
Temperature	°F.		375-600	350-600
Pressure	psi		6,000-30,000	6,000-30,000
Mold Shrinkage (Average)	in./in.		.004-.005	.004-.005
Extruding Temperature	°F.		350-450	350-450
Calendering Temperature	°F.		350-400	325-400
ELECTRICAL				
Dielectric Strength Short Time ⅛"	Volts/Mil	D149-55T	312	351
Volume Resistivity (35% Relative Humidity at 73°F.)	Ohm/Cm.	D257-54T	1.8 x 10^{13}	1.1 x 10^{13}
Dielectric Constant		D150-54T		
60 CPS		"	4.76	4.15
1000 CPS		"	4.45	4.20
10^6 CPS		"	3.78	3.61
3000 x 10^6 CPS		"	2.76	2.70
Dissipation Factor		D150-54T		
60 CPS		"	0.021	0.015
1000 CPS		"	0.002	0.002
10^6 CPS		"	0.026	0.026
3000 x 10^6 CPS		"	0.006	0.006
Loss Factor		D150-54T		
60 CPS		"	0.101	0.062
1000 CPS		"	0.010	0.007
10^6 CPS		"	0.099	0.094
3000 x 10^6 CPS		"	0.016	0.015

*Specific gravity of colors will vary with the pigmentation used.
†Heat distortion of 225°F. is obtained by annealing for 2 hours at 220°F.

These KRALASTIC materials are arranged in order of decreasing Impact Strength except J, L and HTHT, which have special outstanding properties.

Pipe, valves, and fittings of Kralastic are extremely tough, noncorroding, easy to install, approved for drinking water. A proven superior product in over 9,000 miles of installation.



Large formed parts have high dimensional stability, excellent resistance to most chemicals, and high mechanical strength even in thin sections.

Distinctive Properties:

- High impact resistance
- Extreme toughness combined with hardness
- Lightweight: ½ weight of aluminum; 1/7 weight of iron
- Noncorrosive, nonelectrolytic
- Readily sawed, drilled, and threaded
- Quickly solvent welded
- Dimensionally stable over a wide temperature range
- Opaque built-in colors

Major Uses:

- Pipe and pipe fittings
- Light wheels, gears and pulleys
- Durable hair combs
- Machine housings and parts
- Textile warp tubes and bobbins
- Radio and camera cases
- Football and safety helmets
- Tote boxes
- Hose nozzles and fertilizer injectors

RALASTIC 2907	KRALASTIC MM (Formerly Kralastic 2590)	KRALASTIC D	KRALASTIC J	KRALASTIC L	KRALASTIC HTHT
1.06	1.07	1.05	1.02	1.02	1.08
1.5-3.5	0.7-1.5	0.4-1.3	6-9	5-7	3-4
1.8	0.7	0.4	5-6	3-5	2.0-2.5
0.3-0.8	0.4	0.4	1-3	1.5-2.5	0.3-0.5
30-50	20-30	23-33	25-35	30-45	30-50
—	—	23-33	25-30	—	20-30
—	—	10	—	30-40	15-25
25	20	8	35-40	30-40	10-15
10,500	11,000	9,000	4,000	5,600	10,000
350,000	370,000	430,000	190,000	200,00	290,000
11,500	13,500	11,500	4,000	6,500	12,000
400,000	450,000	390,000	170,000	275,000	370,000
7,800	8,800	6,500	3,000	4,000	8,000
115	118	108	62	88	116
0.000042	0.000032	0.000047	0.000073	0.000048	0.000038
1.6	1.8	1.7	2.1	2.3	2.5
0.00057	0.00062	0.00058	0.00072	0.00079	0.00086
.37	.38	.37	.38	.40	.37
198	200	193	172	175	225†
0.3	0.3	0.2	0.2	0.2	0.2
1.8-2.0	1.8-2.0	1.8-2.0	1.8-2.0	1.8-2.0	1.8-2.0
325-400	325-400	325-400	325-400	325-400	350-500
1000+	1000+	1000+	1000+	1000+	1000+
375-600	350-600	350-600	350-600	350-600	400-600
6,000-30,000	6,000-30,000	6,000-30,000	6,000-30,000	6,000-30,000	6,000-30,000
.004-.005	.004-.005	.004-.005	.004-.005	.003-.004	.004-.008
350-400	350-450	350-450	350-450	350-450	400-500
—	—	325-400	300-375	300-375	—
385	386	350	340	384	363
$>2.7 \times 10^{15}$	$>2.7 \times 10^{16}$	$>10 \times 10^{13}$	0.54×10^{13}	1.3×10^{13}	$>10 \times 10^{13}$
3.17	3.10	3.41	4.00	3.70	3.54
3.12	3.08	3.54	4.47	3.52	3.43
3.08	3.02	3.20	4.05	3.48	3.24
—	—	2.66	2.80	—	—
0.005	0.004	0.009	0.011	0.073	0.034
0.005	0.005	0.002	0.002	0.008	0.012
0.009	0.010	0.017	0.018	0.020	0.021
—	—	0.003	0.008	—	—
0.016	0.012	0.030	0.043	0.270	0.120
0.016	0.015	0.005	0.010	0.028	0.040
0.028	0.030	0.053	0.072	0.069	0.067
—	—	0.009	0.021	—	—

Naugatuck VIBRIN

LIQUID POLYESTER RESINS

With the aid of a catalyst, these unsaturated liquid polyester resins are rapidly converted to solids with little or no heat or pressure other than the exothermic heat created by their chemical reaction. Being 100% reactive, they evolve no gas or liquid during cure.

Vibrin resins are used primarily with glass or other fibers in the form of cloth or mat to produce thermosetting reinforced plastic products which are extremely strong and impact resistant.

Naugatuck is a major supplier of polyester resins for hand lay-up, matched metal die, pressure bag and spray molding of large parts. In the booming boat-building field, Naugatuck is the leading resin supplier.

In addition to a wide range of resins for every type of molding, Naugatuck also offers Vibrin VPA parting agent for easy mold release and several types of shell coatings to give a smooth, nonporous, pigmented outer surface to Vibrin moldings.

Distinctive Properties:

Vibrin, reinforced with glass fibers, has these properties:

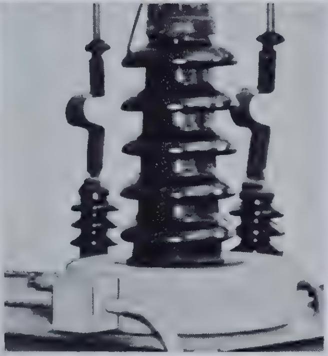
- **Stronger per pound than steel**
- **Economical for large prototype production in small or moderate quantities**
- **Nondenting; impact resistant**
- **Chemical and weather resistant**
- **Can be pigmented or painted over**

Major Uses:

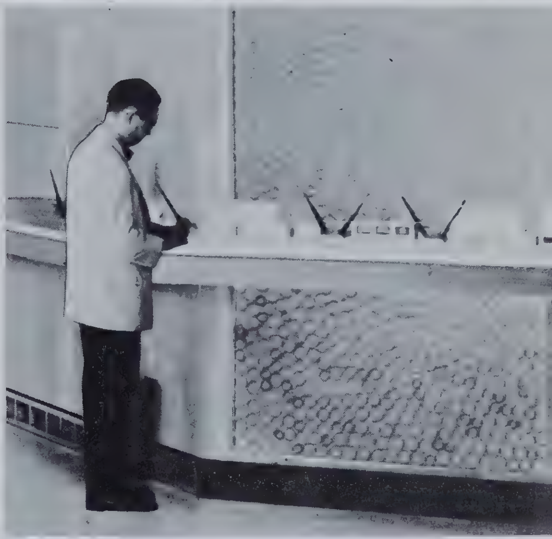
- **Boat hulls and deck units**
- **Auto and truck bodies**
- **Sectional swimming pools**
- **Translucent windows and skylights**
- **Chemically inert pipe**
- **Furniture**
- **Corrugated paneling**
- **Machine housings**
- **Fishing rods**
- **Cements and putties**

TYPE	VIBRIN 115A	VIBRIN 117* VIBRIN 152†	VIBRIN 121	VIBRIN 135 AND 136A	VIBRIN 151	VIBRIN 152-LS-4	VIBRIN 157
DESCRIPTION	**Rigid, Heat-Resistant** Clear, light, liquid polyester resin of high reactivity.	**General Purpose** Clear, light, liquid polyester resins with moderate exothermic properties. *Low viscosity †High viscosity	**Flexible** Clear, liquid, slightly amber polyester resin.	**High-Heat Resistant** Clear, liquid triallyl cyanurate polyester resin.	**Resilient** Clear, liquid polyester resin providing high resilience.	**Light Stabilized** Medium viscosity liquid polyester resin stabilized to prevent light discoloration.	**Hand Lay-up Boat Resin** Thixotropic, pink opalescent polyester resin containing promoter.
SPECIAL FEATURES	Resistant to distortion and degradation at high temperatures. Superior chemical resistance. Good translucency with glass fibers. Excellent laminate mechanical properties. Light color. Approved under MIL-R-7575A, Types I, II and III.	Low exotherm. Good translucency with glass fibers. Air cure. Light color. Approved under MIL-R-7575A, Types I, II and III.	Cures to a flexible thermoset solid and will increase the toughness of rigid VIBRINS.	High strength retention at 500° F. Short-term exposure at higher temperatures. VIBRIN 135 approved under Military Spec. MIL-R-25042. VIBRIN 136A provides craze resistance and improved strength at 500° F. and over.	Elongates 5%. Has outstanding toughness and impact strength.	Shows minimum surface erosion and change in color from sunlight and weather exposure.	Fast cycle time to full cure. Low shrinkage and warpage. Low-heat build-up in thin and medium sections. Reduced odor. Minimum catalyst requirements.
RECOMMENDED USES	Making hand lay-up molds. Matched metal die molding. Laminating.	General fabrication using hand lay-up, vacuum and pressure bag or matched die molding methods.	Combination with rigid VIBRINS to increase toughness and flexibility and for producing flexible thermoset laminates or castings.	Aircraft, missiles, jets, radomes, heat-resistant parts. High temperature electrical parts. Potting.	Impact-resistant products. Pressure bag, vacuum bag or hand lay-up molding and patching putties.	Flat or corrugated panels for colorful outdoor and architectural purposes.	Designed for fast production cycle required by the boat industry. Hand lay-up, room temperature cure uses: boats, pools, tanks, etc.

Complete freedom of hull design, exceptional resistance to damage of any kind, together with ease, speed and economy of production have made Vibrin the boating industry's most popular resin.



Potting of electrical equipment of all kinds provides outstanding resistance to chemical attack, electrical breakdown, unexcelled physical protection.



Architectural and decorative panels of Vibrin have been proved through years of outdoor use, offer a combination of strength, light weight and durability for an infinite variety of translucent and opaque applications.

IBRIN 158	VIBRIN 159	VIBRIN X-1088B	VIBRIN X-1109	VIBRIN X-1111A	VIBRIN X-1112	SHELL COATINGS
ray Applied and Lay-up ixotropic, twin-zzle spray gun sin.	**Hand Lay-up Boat Resin** Medium viscosity, clear amber, promoted polyester resin.	**Minimum Shrinkage Potting Resin** Clear amber polyester resin containing promoter. Low specific gravity.	**Spray Applied Hand Lay-up** Thixotropic, twin-nozzle spray gun resin.	**Semi-rigid Patching Compound Resin** Promoted, clear green polyester resin.	**Flexible Patching Compound Resin** Promoted, clear green polyester resin.	**Surfacing Resins** Natural or white pigmented resins. Colored shellcoats made to order.
ow exotherm, ow shrinkage, 0% lighter eight. o sagging, ast wetting.	Low exotherm, low shrinkage, 10% lighter weight. Ready to use with catalyst addition.	Minimum exotherm and shrinkage. Ready to use after catalyst addition. Light weight.	Fast cycle, light color, no sagging, fast wetting.	Fast gel, one-tube patching system. Semi-rigid, exceptionally long storage life. High adhesion to metal and other surfaces. For liquid or dry catalyst systems.	Flexible, soft, fast gel, one-tube patching system. Exceptionally long storage life. High adhesion to most surfaces. For liquid or dry catalyst systems.	Impact resistant. Excellent aging. Prevents fiber show-through. Does not crack or craze on aging.
oom or elevated mperature red parts, such boats, pools, uck and to parts, nks, etc.	Hand lay-up, room-temperature cure application, such as boats, pools, tanks, especially where thicker laminate sections are employed.	Potting, encapsulating, cements, where minimum stress build-up is important.	Room or elevated temperature cured parts, such as boats, pools, truck and auto parts, tanks, etc.	Compounding patching putty for automotive repair, industrial, marine and household uses. May be blended with Vibrin X-1112.	Compounding flexible patching putty for automotive repair, industrial, marine and household uses. May be blended with Vibrin X-1111A.	Surfacing resin layer for molded products.

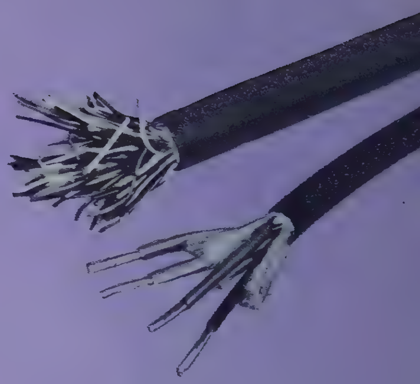
Naugatuck MARVINOL

POLYVINYL CHLORIDE RESINS

Polyvinyl chloride resins and their host of varied uses are well known to the industry. As a major supplier of vinyl resins, Naugatuck is constantly developing additional Marvinol® resins of high, medium and low molecular weights, with specific processing and end-product qualities.

The 13 Marvinol resins listed below constitute what is probably the most extensive line of straight PVC resins available for calendering, etc. from any one manufacturer. Of these, VR-22 and VR-23 electrical grade extrusion resins have Underwriters' Laboratories, Inc. approval. Marvinol VR-24 is used in semi-rigid insulation for low-voltage communications wiring insulation where UL approval is not required.

Particularly outstanding in the Marvinol line are the new resins, VR-50 and VR-51, recommended for plastisol and organosol applications, since Naugatuck has taken the lead in developing exceptional rheological characteristics in these resins.



Wire and cable insulation of Marvinol car
permanently color coded, has excellent e
trical properties, resists abrasion, chemi
attack, and atmospheric deterioration.

	MARVINOL VR-10	MARVINOL VR-12	MARVINOL VR-22	MARVINOL VR-23
Description Typical Properties	Modifying resin for plastisol compounding.	Specialty calendering and extrusion resin.	Electrical grade, hot, dry blend resin for extrusion.	Electrical grade, easy processing, hot, dry blend resin for extrusion and calendering.
Special Features	High molecular weight resin for modifying plastisol formulations. Imparts dryness of hand (dullness), maintains high physical properties, produces lower Brookfield viscosities, promotes good air release in slush and rotational molding plastisol compounds. Used in blown film formulations for high physicals and speeds.	High molecular weight straight PVC resin for imparting special qualities of dry hand (dullness) coupled with excellent physical properties. Demonstrates fast milling and Banbury mix characteristics together with high premix densities in plasticized formulations. Has outstanding high-speed extrusion properties permitting close dimensional tolerances.	Medium-high molecular weight with high bulk density for large Banbury charges. Excellent mixing cycles for hot, dry blend extrusion. Possesses excellent electrical properties and is approved by Underwriters' Laboratories, Inc. for electrical applications. Inherent heat stability.	Medium molecular weight with high bulk density for large Banbury loadings. Fast extrusion rates at low power consumption for dry blends or compounds. Superior electrical properties approved by Underwriters' Laboratories, Inc. for electrical applications. Excellent heat stability.
Resin Properties				
Specific Viscosity	0.52	0.52	0.44	0.38
Apparent Density lbs./cu. ft.	28	25	29	30
Particle Size, microns	7	8	30	27
Acetone Solubility—%	20	20	25	40
Specific Gravity	1.40	1.40	1.40	1.40
ASTM Oil Absorption	0.63	0.95	0.90	0.90
Methanol Extractible	—	—	—	—
Compound Properties* (100 parts resin, 50 parts DOP)				
Shore "A" Hardness	82	82	80	79
Tensile Strength, psi	2900	2900	2800	2600
Ultimate Elongation, %	340	340	340	320
100% Modulus, psi	1475	1475	1500	1450
Tear Strength, lbs./in.	480	480	450	420

MARVINOL VR-24

Easy processing, calendering and extrusion resin.

Medium-low molecul
weight straight PVC.
Very high bulk densit
valuable processing characteristics in semi-rigid calender formulations. With higher molecular weight resins acts as
processing aid.
Useful in rigid and semi-rigid wire extrusion compounds.

0.30
34
25
51
1.40
0.61
—

77
2200
270
1300
370

*Co
ma

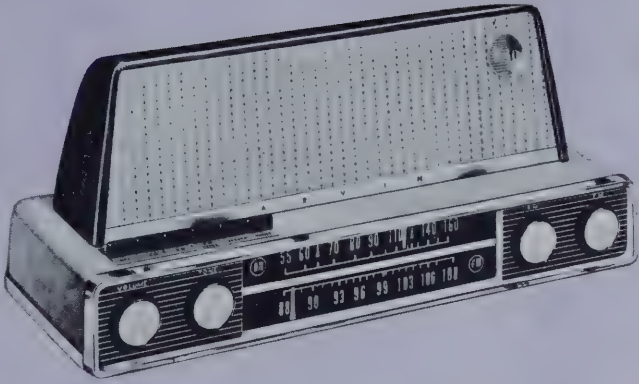
Naugatuck MARVIBOND*

VINYL-TO-METAL LAMINATING PROCESS

The Marvibond process, developed and patented by Naugatuck, is a technique for laminating a specially formulated semi-rigid Marvinol vinyl film or sheeting to almost any kind of sheet metal on a continuous basis. The vinyl provides a permanent, durable and rich-looking finish while the metal supplies structural strength.

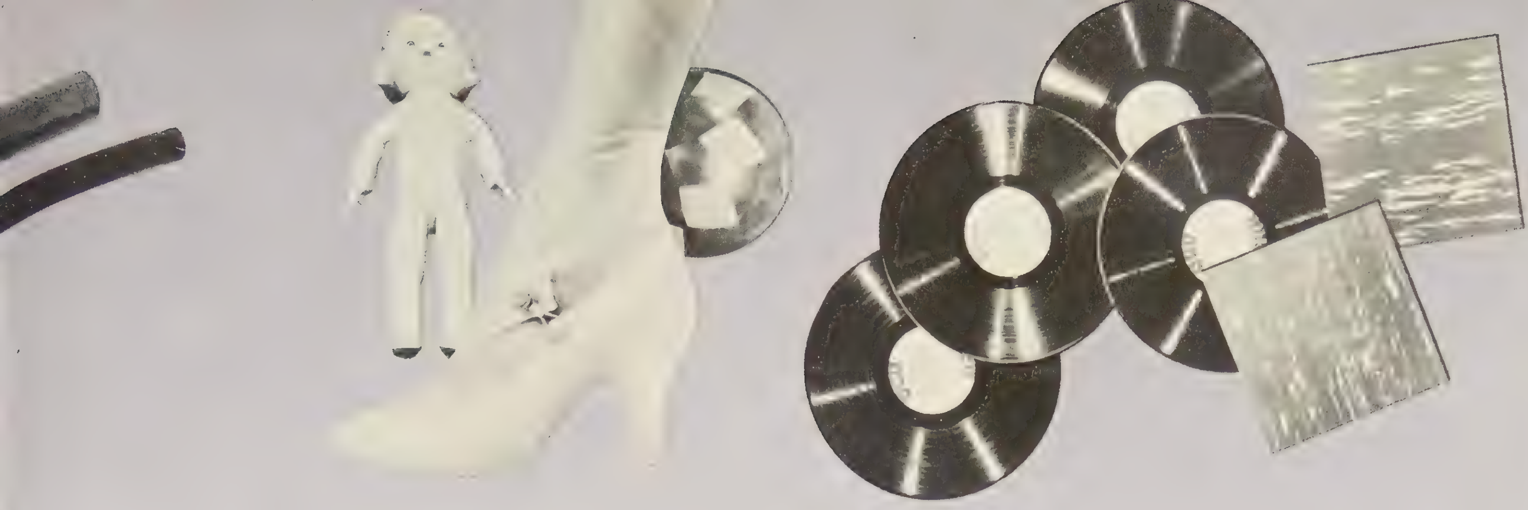
Marvibond laminates can be embossed, sheared, drawn, drilled or crimped using standard metalworking equipment. The items shown below only begin to suggest the product possibilities. Marvibond laminates are available from a number of laminators. Write us for the current list of Marvibond licensees.

*U. S. Pat. No. 2,728,603



Appliance and other housings and cabinets of Marvibond provide colorful, patterned beauty that is completely unharmed by normal bumps and scrapes, yet are easily formed to graceful shapes by normal metalworking methods.

Interior and exterior panelling of Marvibond gives prefinished beauty that will never wear off, stays warm and pleasant to the touch, comes clean with a wipe and resists even extremes of weather.



Marvinol's superior plastisols are easy to use, provide products noted for their toughness, smoothness and uniformity, resist tearing, flex-cracking and puncture.

Records, floor tile and a wide variety of other products are given new processability, new toughness and stability . . . more production economy and more product quality.

Distinctive Properties:

Marvinol vinyls may be compounded to yield products having these properties:

- Extreme versatility — from transparent, clear, flexible film to opaque, hard, nonplasticized rigids
- Light weight
- Strength and toughness
- Inert to most chemicals
- Excellent electrical properties
- Weather and abrasion resistance
- Flame resistance

Major Uses:

- Upholstery fabrics
- Garden hose
- Foamed vinyl sponge
- Drapes and shower curtains
- Doll bodies and toys
- Wire insulation
- Luggage and handbags
- Pipe and tubing
- Floor tile
- Laminates

MARVINOL VR-24	MARVINOL VR-25	MARVINOL VR-26	MARVINOL VR-31	MARVINOL VR-33	MARVINOL VR-34	MARVINOL VR-50	MARVINOL VR-51	MARVINOL VR-60
Easy processing, calendering and extrusion resin.	Low molecular weight processing-aid resin.	Very low molecular weight processing-aid resin.	Cold, dry premix resin for calendered film, sheeting, and coated fabrics.	Cold, dry premix resin for calendered film, sheeting, and coated fabrics.	Easy processing, cold, dry premix resin for calendered film, sheeting, and coated fabrics.	General purpose plastisol resin. Outstanding for high shear and organosol applications.	Special purpose plastisol resin for low shear applications and vinyl foam.	Copolymer resin for phonograph records and rigid applications.
Medium-low molecular weight straight PVC. Very high bulk density, valuable processing characteristics in semi-rigid calender formulations. With higher molecular weight resins acts as a processing aid. Useful in rigid and semi-rigid wire extrusion compounds.	Low molecular weight straight PVC resin ideally suited for: A. An additive in vinyl-asbestos flooring formulations. B. Injection molding of unmodified rigid PVC applications as well as homogeneous floor tile.	Lowest molecular weight straight PVC resin commercially available. Wide application with vinyl acetate copolymers in asbestos flooring and phonograph records. Very low processing temperatures and excellent heat stability.	Medium-high molecular weight. Gives cold, dry premixes. Leaves mixers clean and minimizes clean-out problems. Excellent for the calendering of film, sheeting, and coated fabrics.	Medium molecular weight, cold, dry premixing resin. Leaves mixers clean and minimizes clean-out problems. Excellent for calendered inflatable film, for sheeting, and for coated fabrics. Excellent heat-sealing properties. Produces outstanding injection-molding compounds.	Medium-low molecular weight, cold, dry premixing resin. Minimizes mixer clean outs. Mills and Banburys rapidly. Used for calendering film for inflatables, sheeting, and coated fabrics where an outstanding easier-processing resin is required.	Readily stirred into plasticizers to form low viscosity plastisol at both high and low shear rates. Excellent for spread coating on fabric and paper, organosols and modified plastisols, sprayed coatings, and dipping.	Readily stirred into plasticizers to form plastisols characterized by low Brookfield viscosity and outstanding air release properties. Excellent for slush molding, rotational casting, and open and closed cell foam.	Low molecular-weight vinyl acetate copolymer exhibiting excellent flow and exceptional heat stability. High density for large Banbury charges and faster fluxing. Short preheating time for optimum biscuit flow in record molding. High fidelity reproduction and very low background noise level.
0.30	0.25	0.20	0.44	0.37	0.34	0.50	0.50	0.20
34	38	38	21	21	21	15	15	35
25	25	29	14	15	16	1.7	1.7	17
51	62	70	31	46	48	22	25	100
1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.35
0.61	0.53	0.50	1.65	1.65	1.60	—	—	0.60
—	—	—	—	—	—	1.3%	3.0%	—
77	75	73	80	78	78	Test Recipe VR-50 100 DOP 60 160 Severs Viscosity (2 hrs.) @ 100 PSI 120 poises Brookfield Viscosity (24 hrs.) #5 spindle, 5 RPM, 25,000 cps. Gelation Temperature† 175° F †In Resin 100/70 DOP	Test Recipe VR-51 100 DOP 70 170 Brookfield Viscosity (24 hrs.) #4 spindle, 2 RPM, 15,000 cps. Huff Air Release, 50 secs. Gelation Temperature 190° F	
2200	1400	1200	2800	2800	2400			
270	250	230	360	350	320			
1300	1200	1050	1425	1450	1350			
370	280	200	460	410	400			

*Compound properties shown in the table above have been tested on the same equipment. Comparison with similar figures on resins of other manufacturers can be very misleading, since values obtained on different equipment may vary widely even though the same methods are used.

Naugatuck MARVIBOND*

VINYL-TO-METAL LAMINATING PROCESS

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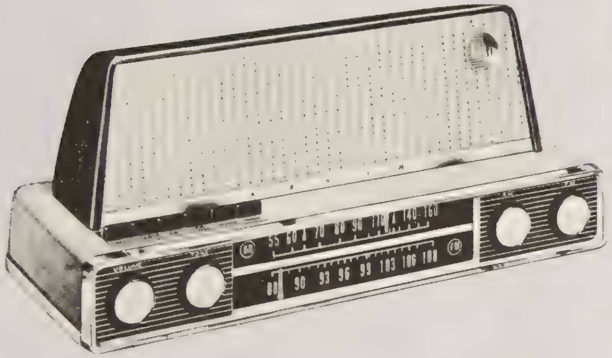

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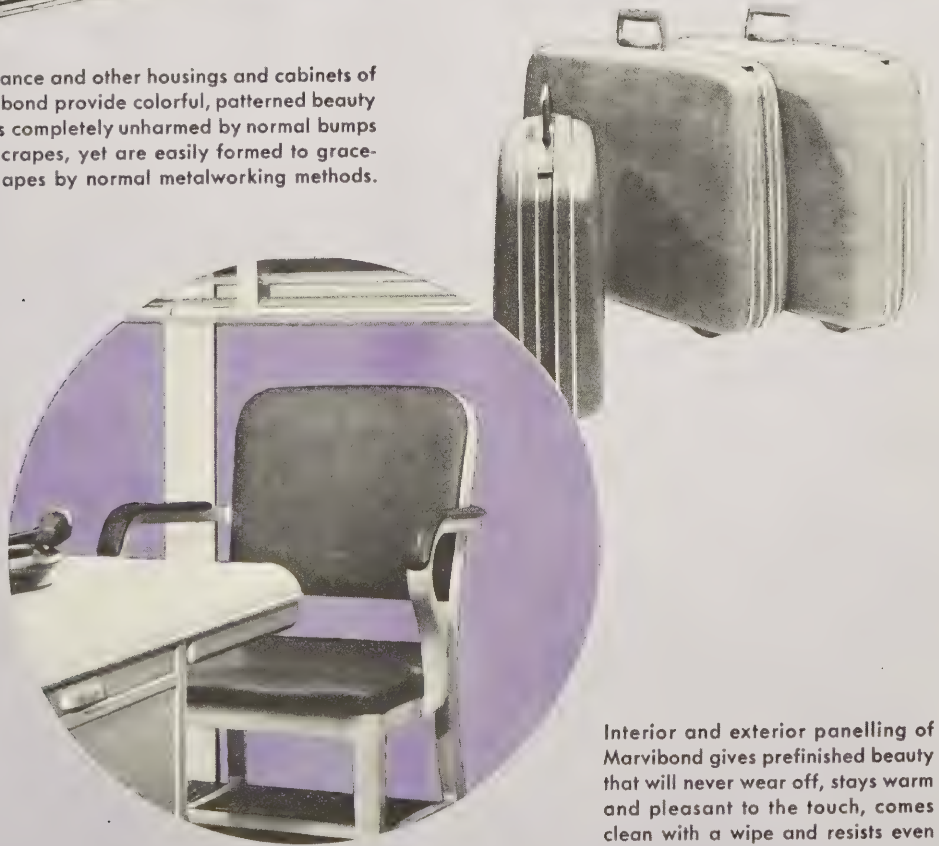

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Other Naugatuck Products for the Plastics Industry

Polygard®

an excellent heat stabilizer for high-impact polystyrene and other rubber reinforced plastics.

Tonox-PL

an aromatic diamine curing agent for epoxy resins. Imparts high heat distortion, excellent chemical resistance, and good electrical properties at low cost.

Celogen®
Celogen-AZ®

blowing agents for polyethylene, polyvinyl chloride, epoxies and other plastics. For lightness, buoyancy, thermal insulation, and improved electrical properties.

Naugatuck Technical Service

Expert technical assistance in the selection, formulation, and application of all Naugatuck resins is available from any of the District Sales Offices listed below. If your problem is complex, it will be referred to our research and development men at our Naugatuck laboratories.

United States Rubber

Naugatuck Chemical Division, NAUGATUCK, CONNECTICUT

Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices

General Sales Office . . . Naugatuck, Connecticut . . . Tel. Park 9-5241

DISTRICT SALES OFFICES:

Boston . . . P.O. Box 2116 . . . Davis 6-6000
New York . . . 1230 Avenue of the Americas . . . Circle 7-5000
Philadelphia . . . 5670 Rising Sun Avenue . . . Pilgrim 2-7000
Akron . . . Pilgrim Square, 9 Overwood Rd. at West Market . . . University 4-2145
Gastonia, N. C. . . . 214 West Ruby Avenue . . . University 4-3411
Chicago . . . 4135 South Pulaski Road . . . Cliffside 4-5700
Los Angeles . . . 5901 Telegraph Road . . . Raymond 3-9971
Memphis . . . 1480 North Thomas Street . . . Jackson 7-2411

FOREIGN SALES OFFICES:

Naugatuck Chemical International . . . 1230 Ave. of the Americas, New York 20, N.Y. . . . Circle 7-5000
Canada . . . Naugatuck Chemicals, Elmira, Ont. . . . Mohawk 9-5466

CABLE ADDRESS . . . Rubexport, N.Y.

Naugatuck distributors are located in the principal cities of the world.

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an aromatic diamine curing agent for epoxy resins. Imparts high heat distortion, excellent chemical resistance, and good electrical properties at low cost.

Celogen®

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Resins in coatings

By Harry Burrell*

Many of the polymers used for molding are also suitable for the manufacture of lacquers, varnishes, paints, and enamels. The principal difference is that coatings polymers are of relatively low molecular weight, a range of 2000 to 10,000 being common. Such low values are required because solution viscosity is perhaps the most important criterion governing the use of resins in coatings. Not only does low molecular weight produce low viscosity but it also greatly increases the number and classes of solvents which can be used.

The function of a solvent in a coating is analogous to the use of heat in molding: it serves to plasticize the polymer temporarily during the actual application. Once the coating is on its substrate, the solvent must evaporate as quickly as practical. Since a solvent serves only a temporary purpose and is eliminated from the final film, it must be as inexpensive as possible.

Another desirable characteristic of coatings resins is for them to be highly amorphous. Polymeric crystallinity promotes insolubility.

Coatings terminology

Terms such as paint, varnish, lacquer, enamel, etc., have specialized meanings for some end uses. Consequently, it is impossible to give an accurate universal definition for these terms. In general, however, varnishes and lacquers are transparent coatings which dry by different mechanisms. Lacquers dry solely by solvent evaporation; varnishes polymerize by reaction with atmospheric oxygen.

Resins used in lacquers must be of sufficiently high molecular weight to form a hard, tough film upon solvent evaporation. Since mechanical properties improve with increasing molecular weight this requirement is opposed to low solution viscosity. The practical compromise is to use more solvent and decrease the amount of resin in solution. This is undesirable, not only because of the increased solvent cost, but also because multiple coats may have to be applied to build a satisfactory film thickness. Lacquers have a considerable advantage in speed of dry, however, and this may be of paramount importance where production schedules must be met.

If time is of secondary importance, a clear varnish may be more satisfactory. Varnishes are normally much higher in solids so that one coat may provide sufficient film thickness. This class of material usually consists of a blend of a resin with a drying oil, achieved by heating together the resin and the oil, such as linseed or tung, at temperatures near 500° F. Some limited polymerization occurs during cooking, which leads to higher viscosity. Such combinations are soft and sticky and do not form protective films until final polymerization takes place.

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Fusion bond finishes *(Corvel)*, which are powders especially prepared for use in a special finishing process *(Whirlclad*, available under license from Polymer Processes, Inc.) are now available in cellulosic, vinyl, epoxy, nylon, polyethylene, and polyether resins. Finishes are applied by dipping heated object, usually metal, into a bed of dry powders . . . powders bond by fusion to the surface of the part . . . coverage is uniform, including sharp edges, corners or projections . . . no sags, drip marks, or bridging at intersections . . . available in colors with controlled sheen. Finishes are applied for chemical and corrosion protection, electrical insulation, wear resistance or surface texture and warmth of feel.

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* Manager, Resin Development Lab., Interchemical Corp., Finishes Div., 1754 Dana Ave., Cincinnati 7, Ohio.
Recent Developments and References were prepared by the editors.

means any liquid coating material containing pigment, intended to hide and decorate a surface. An enamel is a paint which carries a high pigmentation for improved hiding power, and which usually dries to a glossy surface. Household enamels usually have varnish type vehicles and will air dry, but most industrial enamels must be baked.

In fact, most industrial finishes are dried with the use of heat, no matter how they are classified. This practice not only speeds up drying schedules, even of coatings which dry by solvent evaporation, but also allows chemical reactions other than oxidation to promote polymerization. Heat also makes practical the use of slowly evaporating solvent.

Choice of resins

The choice of a resin is obviously controlled by the physical and chemical characteristics required by the end use of the coating. It is always a compromise. In the discussion which follows, the various types of resins available will be considered and both desirable and undesirable characteristics will be described. The end user must base his final decision on what most closely approximates his requirements.

Natural varnish resins

A number of so called "natural resins" are used for varnishes, of which rosin and its derivatives are most prevalent. Other natural varnish resins are generally named for the geographical location from which they are shipped; these include congo, manilla, copal, kauri, etc. Shellac and zein (corn protein) are also natural resins used in coatings, but since they are not oil-soluble they are used in alcohol solution as special lacquers.

Synthetic varnish resins

Because of the uncertain supply of natural resins and quality variations in them, synthetic varnish resins have been developed. These embrace both the thermosetting and thermoplastic types and a whole coatings technology has been built up around them. The advantages of color, durability, and fast drying have resulted in their superseding natural resins almost completely for industrial applications.

Thermosetting resins

Alkyd resins: By far the most important coatings resins, alkyds surpass their nearest competitors four- or fivefold. The hard resin component of alkyds is glycerol phthalate. However, glycerol phthalate is not oil-soluble: in fact, being thermosetting, when fully reacted it is insoluble in everything.

In order to combine glycerol phthalate with an oil, the oil must be taken apart and then recombined with glycerol and phthalic anhydride. In some cases, rather than splitting the oil into its components, the whole oil is first cooked with the additional glycerol and a catalyst to prepare a mixture of glycerol esters with which the phthalic will react. In either case, the product is a sticky semisolid which must be sold as a solution in hydrocarbon solvent to accommodate handling. Instead of glycerol, pentaerythritol or other polyhydric alcohols are often used. To a lesser extent phthalic anhydride is sometimes replaced with adipic, maleic, or other dibasic acid.

The properties of alkyds are altered principally by controlling either the kind of oil or fatty acids used or the "oil length" which refers to the ratio of oil to glycerol phthalate. Unsaturated fatty acids such as tung or linseed contribute to excellent dry, toughness, and weather resistance but also result in darker colors. Fatty acids such as coconut or pelargonic produce very pale colors but do not contribute much to toughness and are "nondrying." Very large amounts of soy alkyds are used because soy oil provides a convenient, economical compromise which permits good dry with fair color.

Approximately 50% oil is about the optimum amount for best water resistance and outdoor durability. Increasing the proportion of fatty acid naturally results in a softer, less viscous, and less glossy resin. While decreasing the oil content improves hardness and viscosity, there is a minimum for any particular formulation which will allow a resin to be cooked to a low acid number without premature gelation.

Alkyds containing 50% or more drying oil are used for exterior trim paints and interior enamels. Alkyd based flat or semigloss wall paints are widely used, and are frequently supplied in "odorless" solvents. Another popular variation is the "gelled" or "dripless" type in which a thixotropic brushability is imparted by the addition of a polyamide resin.

Alkyds shorter than 50% are frequently blended with an amine resin for industrial uses. These versatile coating systems provide rapid baking to durable, mar-resistant coatings capable of being produced in any color. In addition, special properties can be obtained such as detergent and hot water resistance for dishwashers, grease and stain resistance for refrigerators, or gloss retention and gasoline resistance for automobiles. The versatility of alkyd and amine resins, plus economy and fast production schedules has made alkyd-amines the workhorse of industrial coatings.

Amine resins: The amine resin components referred to above are made by reacting urea, melamine, or benzoguanamine with formaldehyde and butanol to give water white, hard, brittle resins. When blended with alkyds, a fortunately synergistic combination of properties results which overcomes the inherent brittleness of the amine resins and the softness of the straight alkyds. Not only do such systems have excellent color and gloss but their color and gloss retention remain good when exposed to heat or light.

Commercial amine resins differ not only in the raw material used but also in the amounts of formaldehyde and butanol combined. Such variations permit control of speed of cure, compatibility, and hardness.

Epoxy resins: Epoxies are growing contenders for the presently dominant alkyds. These resins are manufactured from bisphenol and epichlorohydrin; the proportions of raw materials are varied to control molecular weight and epoxy content.

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coatings by two principal routes. The first is through their fatty acid esters. These oleoresinous vehicles are much more resistant to alkalies, detergents and abrasion than alkyd resins and have better adhesion. Epoxies are more expensive than alkyds; even though costs are reduced somewhat when reacted with fatty acids, they are used only in applications where performance justifies the cost, e.g., floor varnishes, porch enamels, and bottle cap overprint varnishes.

Epoxy esters are also used as primers for washing machines and dish washers where adhesion to steel must be maintained in the presence of detergent spillage. Color and gloss retention on exposure to ultra-violet light are not outstanding assets of epoxies, so outdoor exposures are not ordinarily recommended.

To develop the maximum chemical resistance of epoxies, they should be cross-linked through the epoxy oxygen rather than esterified with fatty acid. Use of functional amine or phenolic groups not only serve to cure the epoxies, but the physical properties such as flexibility and hardness can be changed by properly selecting the reactive resin. These so-called "solution epoxy coatings" develop phenomenal resistance to alkalies, acids, and solvents and represent a useful approach to chemical-resistant coatings. They are used in pipe and drum linings and as resistant coatings in corrosive atmospheres.

Polyamides: The nylons used for injection molding or fiber spinning are too insoluble to use in paints. However, modifications can be made which impart enough alcohol solubility so that specialty coatings, such as for wire insulation, can be formulated. This can be done by reacting nylons with formaldehyde and methanol or by using a mixture of dibasic acids such as adipic and sebacic in preparing the original nylon.

Polyamides made from dimer acids are thermoplastic heat-sealable adhesives which are useful for paper containers and packaging. Minor amounts of epoxy resin convert them to soft, flexible, but thermosetting coatings suitable for flexible substrates such as rubber or vinyl moldings. Finally, these polyamides can be formulated with phenolic resins to combine excellent chemical resistance with a degree of flexibility.

Phenolics: The phenol-formaldehyde resins used for molding are made from phenol itself or from methyl substituted phenols. When phenols with larger side chains are used (such as tertiary butyl, amyl, or phenyl) the formaldehyde addition products are soluble in drying oils. Such resins can be produced with controlled quality and impart considerably improved characteristics to varnishes. Water, alcohol, solvent, and weather resistance are generally upgraded. In some cases the drying of the varnish is speeded up, making possible a two- to four-hour drying product; an alternative way of taking advantage of this drying acceleration is to use less expensive but slower drying oils such as soy to make a more economical product. Since substituted phenols are fairly expensive chemicals, the resins produced from them can be extended by blending with rosin and in some cases with cheaper phenols.

So-called "spirit soluble" types of phenolics are also available which are condensation products of formaldehyde with phenol and substituted phenols carried to such a low molecular weight that they remain soluble in alcohol or alcohol-hydrocarbon mixtures. On further heating with acid or basic catalysts they can be converted to an insoluble, infusible form which has excellent water and acid resistance. Such materials have had a long history of satisfactory use in drum or sanitary can linings, but their principal defects are brown color and the extreme brittleness which necessitates very thin films. Much work has been done to correct these deficiences and recently products of improved color and flexibility have become available.

Other thermosetting resins

At least three other thermosetting coating resins are being investigated but so far do not enjoy very wide usage in the United States.

Silicones: As a class, silicones have the principal disadvantage of high cost. They have excellent color, heat and water resistance, outstanding stability, and outdoor durability. To some extent these desirable characteristics can be imparted to blends with alkyds or phenolics, but only at a cost increase which frequently is inconsistent with the improvement in properties.

Polyesters: This term is used to describe blends of glycol-maleic alkyds with styrene. Monomeric styrene polymerizes readily with the unsaturated resin in the presence of peroxides and cobalt compounds. Because the curing reaction is strongly inhibited by oxygen it is customary to include a small amount of wax in the formulation which sweats to the surface and seals it off against oxygen. This requires sanding of the finished surface to develop an attractive appearance. Unfortunately, this hand labor plus the thick layer required has made the use of polyesters relatively unattractive to the coatings industry.

Polyurethanes: Originally developed and now reportedly used extensively in Germany, polyurethanes are susceptible to wide possibilities in formulation because the essential component, a diisocyanate, is so extremely reactive that it tends to cross-link almost any kind of resin blended with it. Polyesters and polyglycols have been most favored as the resinous component. The very reactivity of isocyanates is a handicap since it necessitates a two-package system and rigorous exclusion of water. Difficulties also exist in pigmentation and toxicity. Water and chemical resistance are reportedly superior, but so far the coatings industry has found other means of satisfactorily imparting these characteristics.

Thermoplastic resins

Coatings discussed so far have all been heat reactive or thermosetting in nature. On substrates such as wood, paper, or thermoplastic moldings or massive objects where drying at room temperature or with a severely restricted heat input is mandatory,

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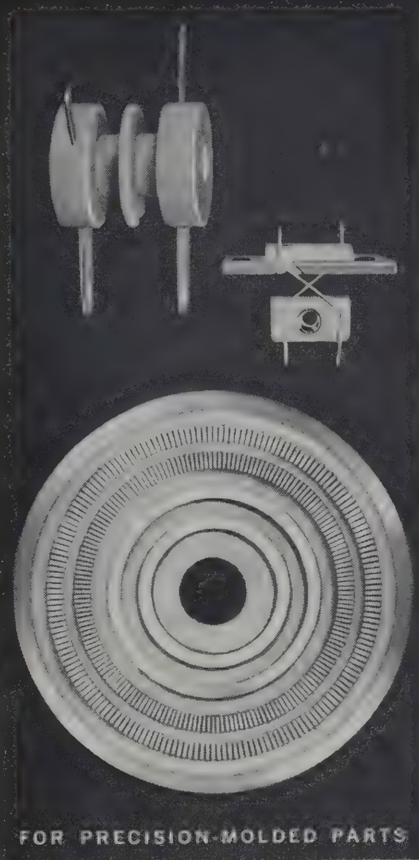
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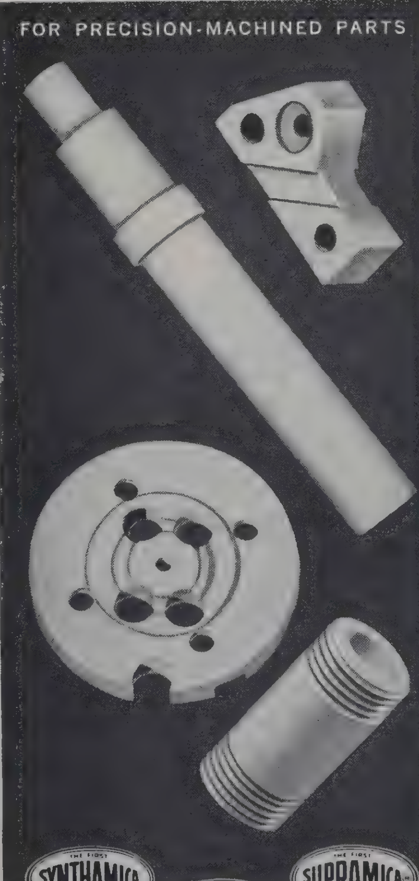
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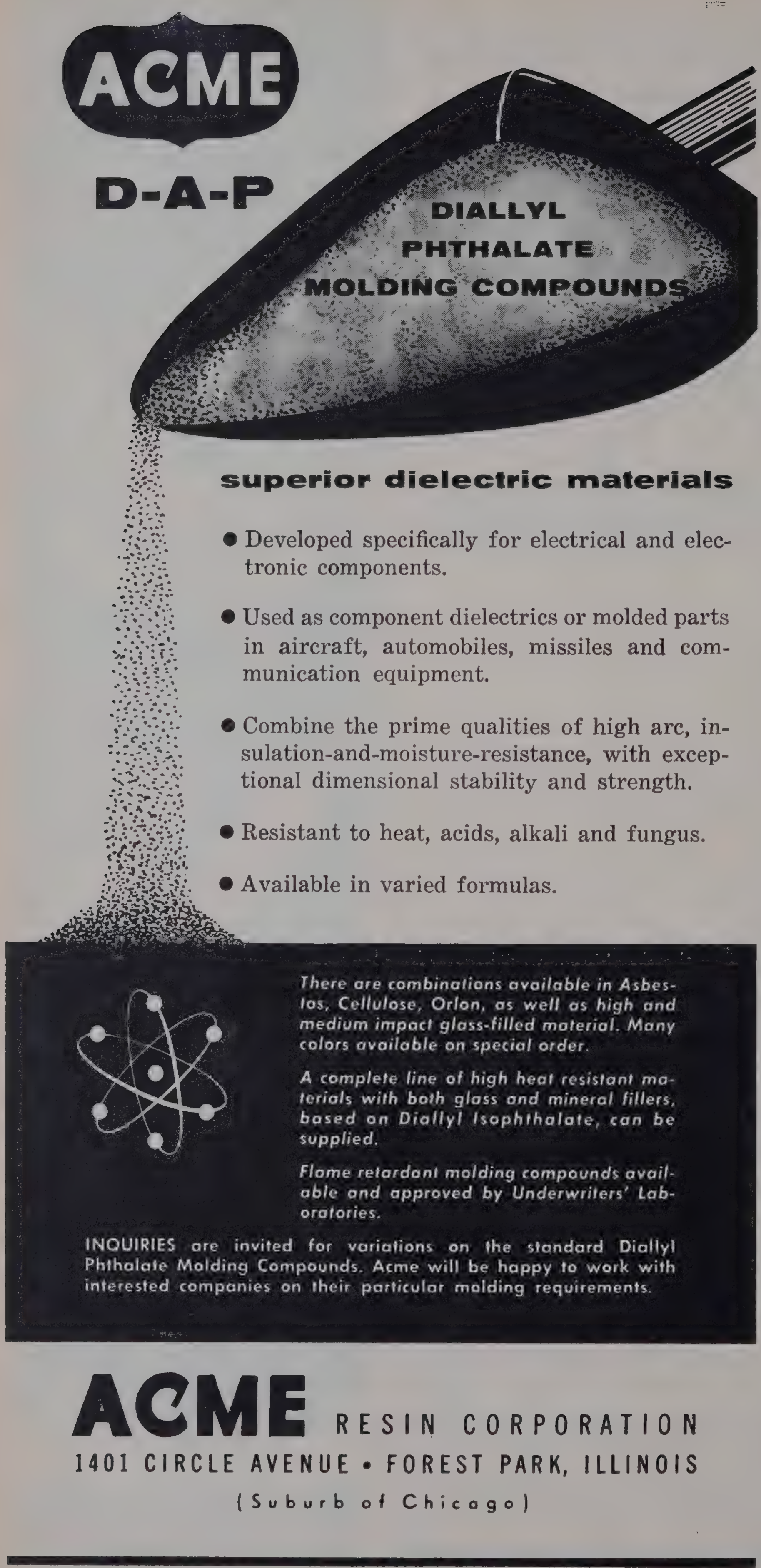

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it is necessary to use resins which are already sufficiently high in molecular weight to provide satisfactorily hard, tough films. At the same time, as explained earlier, the molecular weight must also be low enough to insure solubility. This compromise in molecular weight results in such resins being thermoplastic. Large amounts of such resins are used in both industrial and domestic coatings, although the temperature to which a painted object can be exposed is limited.

Cellulose derivatives: These materials can be varied in molecular weight (viscosity) by hydrolyzing the naturally occurring cellulose chains under controlled conditions; they can also be altered by proper selection of the substituent which is attached to the hydroxyl groups of cellulose.

Cellulose nitrate is made by esterifying cellulose with nitric acid. By controlling the number of nitrate groups the solubility can be changed. The dinitrate is alcohol soluble, and such cellulose nitrate is known as the "SS grade." Slightly higher nitration promotes the ester and ketone solubility regularly utilized in lacquers. Lacquer ("RS grade") cellulose nitrate is supplied in a wide range of viscosities. The low viscosity material, however, has been so degraded that it is lacking in film strength, while high viscosity types allow such low solution solids that only very thin films can be applied. For these reasons, cellulose nitrate is combined with other resins such as alkyds and rosin esters in such ratios that reasonably thick films (0.5 to 1 mil) can be applied and yet will dry very quickly. Since cellulose nitrate tends to be brittle it is usually necessary to include plasticizers.

Cellulose acetate is used to a much lesser extent in coatings because it has very restricted solubility and compatibility with other resins. Cellulose butyrate and acetate butyrate has enjoyed increasing use in recent years because of good solubility and exterior durability, especially in clear coatings for metals.

Ethyl cellulose, chemically a cellulose ether, can be varied over

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even a wider range of solubilities than can the esters. In addition to being used in lacquers, it can even be cooked into oil varnishes.

Vinyl resins: Polyvinyl chloride has such limited solubility that it is not suitable for normal solution coatings. A technique has been developed, however, for using dispersions of resin particles known as organosols. Here the solvent composition is carefully selected to swell the resin just enough to maintain suspension of the particles and to cause their fusion when baked. By this means, unusually high molecular weight resins can be applied, with attendant film toughness, without the complication of high solution viscosity. The normally poor adhesion usually requires special primers.

Polyvinylidene chloride has somewhat better solubility in common solvents but it shares with polyvinyl chloride the defect of poor color stability when exposed to heat or light. Proper formulation can overcome this objection in many cases.

Copolymerizing vinyl chloride with 5% to 13% vinyl acetate improves the solubility greatly, and practical coatings can readily be formulated with these copolymers. They are somewhat easier to stabilize, but adhesion still poses a problem. A terpolymer with improved adhesion is available which contains about 1% maleic acid. Another modification has about 2% of the acetate groups hydrolysed off, and the resulting hydroxyl-containing polymer is compatible with many other resins including alkyds. These vinyl resins provide coatings with excellent initial color, water and acid resistance, toughness, and abrasion resistance.

Other vinyl resins useful in coatings include polyvinyl ethyl ether for pressure-sensitive adhesion; polyvinyl alcohols for water soluble, grease-resistant coatings; and polyvinyl acetate for extreme toughness and durability.

Acrylic resins: Soluble acrylic resins are similar to vinyl esters in having excellent color and, being chlorine free, they exhibit good color retention. They tend to be somewhat harder (especially the methacrylates), have better

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adhesion, and they are generally more expensive. A wide variety of monomeric acrylates is currently available. These allow control of physical properties from hard, somewhat brittle films to tough, rubbery types. Solvent tolerance for inexpensive hydrocarbons is good.

Coatings based on acrylic resins have good resistance to water, alcohol, acids, and oils. They are particularly useful in clears for exterior exposure and in white coatings where light reflection is important.

Styrene-containing resins: Because polystyrene is brittle and has such inferior adhesion, its use in coatings is extremely limited. Styrene copolymers, however, are important raw materials for the coatings industry.

Butadiene-styrene copolymers, which are much higher in styrene content than SBR rubber, produce hard films with good flexibility and adhesion. Water and acid resistance are good, but solvent resistance and color retention are poor. (Water dispersed latices of these resins are discussed in later paragraphs.)

Other important copolymers enjoying considerable usage are the styrenated alkyds. These resins dry with lacquer speed but solids concentrations are much higher than with lacquers. The films tend to be brittle and they have poor exterior durability. However, for large pieces of machinery, toys, etc., their low cost and fast air dry make them very useful.

Hydrocarbon resins: A number of hydrocarbon resins are also used in varnishes. These are discussed in detail in the chapter "Coumarone-indene, petroleum, and polyterpene resins," p. 87.

Miscellaneous thermoplastic resins

Several other resins are used in coatings, but to a much smaller extent than previously mentioned products. Chlorinated rubber, for example, is an excellent base for masonry paints because it maintains adhesion in spite of the alkali in concrete products which soon attacks oil base paints. Polyfluoroethylene, which has greater resistance to acids, alkalies, sol-

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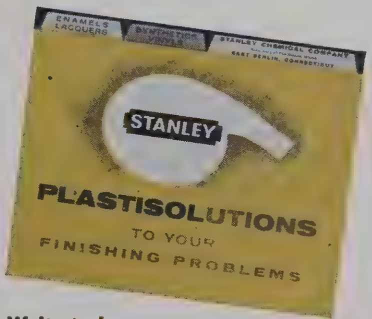

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Freeman Chemical Corporation, a subsidiary of H. H. Robertson Company,
is pleased to announce an important expansion in

PRODUCT LINES
RESEARCH
MANUFACTURING FACILITIES
SALES AND SERVICE

In addition to its plant in Saukville, Wisconsin, Freeman now operates the former Robertson Stypol polyester resin plant at Ambridge, Pennsylvania. Stypol resins—along with the Chempol line of alkyd, urethane and foundry resins, emulsion vehicles and adhesives—will be manufactured at both locations. Freeman Chemical will also market bituminous compounds and copper powders made by Robertson at Ambridge. Freeman Chemical Corporation general offices will remain at Port Washington, Wisconsin.

We at Freeman welcome this opportunity to provide a more diversified group of products, an increased production capacity, added convenience of shipping points and a greatly expanded sales and technical advisory staff to serve you—the members of America's most progressive industry—plastics.

FREEMAN CHEMICAL CORPORATION
PORT WASHINGTON • WISCONSIN

Subsidiary of the H. H. Robertson Company, Pittsburgh, Pennsylvania

STYPOL POLYESTERS • CHEMPOL ALKYDS • URETHANE RESINS • COPPER POWDER
ADHESIVES • FOUNDRY RESINS • BITUMINOUS COMPOUNDS • PVA VEHICLES

vents, and oxidation than any other resin, has been used in certain specialty paints; its high cost and difficulty of application seriously limit its widespread use, however. Neoprene rubber and chlorosulfonated polyethylene have also been used to some extent in corrosive atmospheres.

Polyethylene has many properties which make its use attractive in coatings, such as excellent color, low cost, good resistance properties, etc. Unfortunately, its poor solubility at room temperature makes the usual type of coating impractical. Special techniques such as dispersions, flame spraying, and hot extrusion have been successfully used.

Water thinned coatings

Preceding parts of this chapter have indicated the difficulties inherent in the use of solvents with many resins. In addition, low cost and lack of odor, toxicity, and flammability all highly recommend the use of water as a solvent. Unfortunately, most resins normally used are not soluble in water.

As a result, latices, emulsions, and water dispersions have been developed which have become very popular. For some years the use of styrene-butadiene, polyvinyl acetate, and acrylic latices has continued to grow. Interior wall coatings and exterior masonry paints based on these materials have proved to be very satisfactory.

Latices and emulsions have been less successful in industrial coatings where specifications and requirements are more exacting and where methods other than brushing must be used. This is partly due to inferior water resistance and adhesion characteristics of such materials. As a result, considerable effort has been expended by raw materials suppliers to develop true water solutions of resins which can be cured to a water insoluble condition. Resins have recently been introduced which show considerable promise in this direction.

References

Consult the Subject Index for additional information concerning coatings. See also the Coat-

(*Continued on p. 203*)

4 fine plastics from

KOPPERS

DYLENE®
POLYSTYRENE

SUPER
DYLAN®
POLYETHYLENE

DYLAN®
POLYETHYLENE

DYLITE™
EXPANDABLE
POLYSTYRENE

DYLENE®

POLYSTYRENES

DYLENE is a rigid thermoplastic readily formed by ordinary methods such as injection molding, extrusion and vacuum forming.

Normal DYLENE polystyrenes

TYPE 2	Ease of molding makes it ideal for use with large and/or small, intricate mold designs.
TYPE 3	Fine molding characteristics make it good for general uses where moderate heat resistance is necessary.
TYPE 4	Use where easy flow and fast setup are of critical importance.
TYPE 7	Excellent general-purpose polystyrene with a typical heat distortion temperature of 194°F.*
TYPE 8	Typical heat distortion temperature of 201°F.* is combined with excellent electrical and mechanical properties.

Medium shock-resistant DYLENE polystyrenes

TYPE 30	For appliance parts. Has easy molding characteristics and typical heat distortion temperature of 175°F.*
TYPE 80	Has typical heat distortion temperature of 195°F.*

High shock-resistant DYLENE polystyrenes

TYPE 200	Easy molding and impact resistance make it ideal for large parts such as refrigerator inner door liners, appliance housings, etc.
TYPE 201	Especially designed for sheet extrusions where high luster without overlay is desired.
TYPE 800	Typical heat distortion temperature of 195°F.* and ready moldability are outstanding features of this polystyrene.

EVENGLO® *polystyrene — Specially pigmented* DYLENE *formulations for fluorescent lighting fixtures.*

**By ASTM method D648*

SUPER DYLAN® HIGH-DENSITY POLYETHYLENES *(ASTM TYPE III)*

TENSILE STRENGTH. Pipe made from Super Dylan has three times the short-term burst of strength of conventional lower-density polyethylene. 1-inch IPS Schedule 80 pipe made of Super Dylan has tested over 1,000 psi gauge pressure before bursting (at room temperature). A like pipe of low-density polyethylene burst at 350 psi.

CHEMICAL RESISTANCE. Because Super Dylan is an ethylene polymer, it is not attacked by acids (including hydrofluoric acid which dissolves glass) or alkalies.

HIGH-TEMPERATURE TOUGHNESS. At 15 psi steam pressure in an autoclave, Super Dylan samples displayed maximum observable dimensional reduction of only 4%, while low-density polyethylene became a shapeless mass.

LOW-TEMPERATURE TOUGHNESS. In comparative tests, Super Dylan bars chilled to –100°F. remained intact when subjected to 32 foot-pound per inch of face blow in the Izod Impact test. Lower-density polyethylene snapped.

ENVIRONMENTAL CRACK RESISTANCE. Producers of blown bottles have found that Super Dylan polyethylene of suitable type has demonstrated outstanding environmental crack resistance in the presence of numerous cosmetics, pharmaceuticals and detergents. Similarly, pipe* tests have also shown outstanding performance.

APPEARANCE AND COLORING. Unlike most lower-density polyethylenes, Super Dylan makes products that have a smooth, glossy appearance. Super Dylan is transparent in very thin sections and has a milky-white, translucent appearance in thicker sections. These factors make a wide range of colors possible.

EASE OF PROCESSING. In spite of toughness, improved heat resistance and rigidity, Super Dylan is remarkably easy to process. In conventional molding machines it molds within the normal range of molding temperatures. It usually requires 50°F. higher cylinder temperature than lower-density polyethylene and 30° to 50°F. less heat than many impact-type polystyrenes.

MANY APPLICATIONS. Versatile Super Dylan polyethylene can be used in the manufacture of toys, kitchenware, auto parts, pipes and fittings, bottles and carboys, packaging films, washing machine agitators, refrigerator parts, battery cases and many other products.

**January, 1955 41-GP-5P Canadian Government Specification Board, Provisional Specification for Pipe: Polyethylene for Cold Water Service.*

Typical Physical Properties of Super Dylan Polyethylene

PROPERTY	UNITS	TEST METHOD	RANGE OF VALUES†
PHYSICAL AND MECHANICAL			
Density	g./ml.	ASTM D1505-57T	0.95
*Tensile Strength	psi	ASTM D412-51T (20″/Min.)	3500–5500
		ASTM 638-58T (2″/Min.)	3000–4000
*Elongation in Tension	percent	ASTM D412-51T (20″/Min.)	25–100
		ASTM D638-58T (2″/Min.)	100–400
*Stiffness Modulus (1/16″ Specimen)	psi	ASTM D747-58T	90,000–120,000
*Impact Strength, Notched Izod	ft. lbs./ in. of notch	ASTM D256-56	1–4
Un-notched Izod	ft. lbs./ in. of face	At 21° C. (70° F.)	Over 32
		At –73° C. (–100° F.)	Over 32
*Hardness (Shore D Scale)		ASTM D1484-57T	63–70
Bulk Factor		ASTM D1182-54	1.8
ELECTRICAL			
Dielectric Constant (80 Megacycles)		ASTM D150-54T	2.3–2.4
Dissipation Factor (80 Megacycles)		ASTM D150-54T	0.001
Dielectric Strength, Short Time	volts per mil	ASTM D149-55T	500
Step-by-Step	volts per mil	ASTM D149-55T	475
THERMAL			
Dimensional Stability	percent	10 Min. @ 250° F. (Steam)	2–4
Brittleness Temperature	°C.	ASTM D746-57T	Below—75°C.
*Coefficient of Thermal Expansion	in./in./°C.	ASTM D696-44	12.5 x 10^{-5}
*Mold Shrinkage (Injection)	in./in.	ASTM D955-51	0.02–0.04

Super Dylan Melt Indices Available:

Type	6002	6004	6008	6015	6030	6060	6090	Type 7000-N (nSf Approved Natural and Black for Potable Water Piping)
Nominal Melt Index	0.2	0.4	0.8	1.5	3.0	6.0	9.0	0.2

**Injection molded specimen.*

†For uncolored, unfilled specimens.

DYLITE® EXPANDABLE POLYSTYRENE

—a remarkable foam plastic

Dylite expandable polystyrene has demonstrated its unique versatility by successful application in many different fields: low temperature insulation, packaging, refrigeration, containers, floatation equipment and construction.

Why is it such an outstanding plastic? Because Dylite offers an unusual combination of properties.

DYLITE IS A THERMAL INSULATOR

The thermal conductivity (K Factor) of Dylite at 2 lbs./cu. ft. density is 0.242 at a 75°F. mean temperature. Dylite is highly resistant to the passage of heat and is unaffected by moisture condensate. Its excellent moldability is another prime feature, because it permits Dylite to fit the complicated contours of low temperature equipment.

DYLITE IS WATER-RESISTANT

Dylite's rate of water absorption is 0.9% by volume after 48 hrs. immersion (2 lbs./cu. ft. density). Dylite's rate of water vapor transmission is 1.18 perms. Dylite can remain in water indefinitely because its closed cell structure resists water penetration.

DYLITE IS SHOCK-RESISTANT

Dylite possesses an energy absorption ratio (Maximum Load) of 56.74 in. lbs./cu. in. at a density of 2 lbs./cu. ft. For example, Royal Electric Typewriters are now shipped in Dylite foam packing. The 3½ pound Dylite pack gives the 47-pound typewriter complete protection in shipment.

DYLITE IS LIGHTWEIGHT AND BUOYANT

Dylite is lighter than cork—it can be molded at densities as low as 1 lb./ cu. ft. In packaging, Dylite helps reduce shipping costs and makes handling easier. And, Dylite's lightweight qualities make it ideal for floatation equipment—1 cu. ft. of Dylite will support more than 60 lbs. in water.

DYLITE IS STRONG

At 2 lbs./cu. ft. density, molded Dylite displays a compressive strength of 30 psi and a tensile strength of 55 psi. And, Dylite's strength-to-weight ratio is excellent. Dylite can be used to great advantage to solve a wide variety of design problems. For instance, Dylite chair forms were used in the Futorian Chair and with these significant results: stronger than wood, 66% lighter, and lower manufacturing cost.

DYLAN® POLYETHYLENES (Conventional and Intermediate Density-ASTM Types I and II)

The 1000 and 2000 series DYLAN polyethylenes are soft and flexible, ideal for squeeze bottles, film, injection molding, and packaging where flexibility is important. The 3000 and 4000 series DYLAN polyethylenes are intermediate-density resins, especially suited for pipe, film, and injection molding where properties of superior stiffness and strengths are required.

All DYLAN resins are available in natural, black and colors.

DYLAN resins are numbered to indicate density groups (as explained below left) and melt index (indicated by second and third digits of the new numbers). The "-N" suffix, in a similar fashion, indicates polyethylenes tested and approved by the National Sanitation Foundation Testing Laboratory, Inc., University of Michigan, School of Public Health, Ann Arbor, Michigan, for the production of "nSf"-labelled pipe, suitable for drinking water. nSf types contain carbon black and effective anti-oxidants.

Type	Melt Index (Typical)†	Density*	Recommended Use
1010	1.5	.917	Pipe
1014-N	1.5	.917	nSf Pipe
1020	2.1	.917	Injection Molding
1022	2.1	.917	Film, Bottles, Injection
1023	2.1	.917	Film
1100	10.	.916	Injection Molding
1200	20.	.915	Fast Flow Injection Molding
1220	22.	.915	Fast Flow Injection Molding
2072	7.	.921	Injection Molding
2201	20.	.921	Fast Flow Injection Molding
2350	35.	.922	Fast Flow Injection Molding
3014-N	1.2	.926	nSf Pipe—Injection Molding
3072	7.	.928	Injection Molding
3102	10.	.930	Injection Molding
3202	20.	.930	Fast Flow Injection Molding
4014	1.2	.935	Injection Molding
4014-N	1.2	.935	nSf Pipe

† gm./10 min. * gm./ml.

DYLAN PROPERTIES COMPARISON TABLE

Property	Typical Values for Natural DYLAN polyethylenes†			
	Unit	Test Method	(ASTM Type I)	(ASTM Type II)
Physical and Mechanical:				
Density at 23° C.	g./ml.	ASTM D1505-57T	0.914–0.925	0.926–0.940
Melt Index	g./10 min.	ASTM D1238-57T	1.5–35.0	1.0–20.0
*Tensile Strength, Ultimate	psi	ASTM D638-58T	1200–1950	1300–2200
*Tensile Yield Point	psi	ASTM D638-58T	1400–2000	1500–2500
*Tensile Elongation, Ultimate	percent	ASTM D638-58T	100–650	100–650
*Izod Impact Strength	ft. lb./in. of notch	ASTM D256-56	No break	No break to 4
*Stiffness in Flexure	psi	ASTM D747-58T	13,000–20,000	20,000–35,000
Brittleness Temperature	°C.	ASTM D746-57T	Below —73 to —30	Below —73 to —39
Bulk Factor		ASTM D1182-54	1.7 to 2.0	1.7 to 2.0
Index of Refraction		ASTM D542-50	1.5	1.5
Electrical:				
Dielectric Constant		ASTM D150-54T	2.3	2.3
Power Factor		ASTM D150-54T	0.0002–0.0005	0.0002–0.0005
Dielectric Strength, short time	volts per mil	ASTM D149-55T	450	450
Arc Resistance	sec.	ASTM D495-56T	250	250
Thermal:				
*Coefficient of Linear Thermal Expansion	in./in.°C.	ASTM D696-44	18×10^{-5}	15 to 17×10^{-5}
Thermal Conductivity	cal./sq.cm./sec./°C./cm.		8×10^{-4}	8×10^{-4}
Specific Heat	cal./g./C.		0.5	0.5
*Flammability		ASTM D635-56T	Slow burning	Slow burning

* Injection molded specimen. † For uncolored, unfilled specimens.

DYLENE, DYLAN, SUPER DYLAN, DYLITE and EVENGLO are registered trademarks of Koppers Company, Inc.

Fully detailed and illustrated technical folders are available on DYLAN, SUPER DYLAN, DYLITE and DYLENE plastic materials. They are yours for the asking. If yours is an unusual problem, our staff of technical men are ready to give their help in solving your problems. A call, wire or letter to us will bring technical information and assistance . . . right to your plant. Count on Koppers.

Offices in Principal Cities.

In Canada: Dominion Anilines and Chemicals Ltd., Toronto Ontario

KOPPERS
COMPANY, INC.

Plastics Division
Pittsburgh 19, Pennsylvania

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C-0-135

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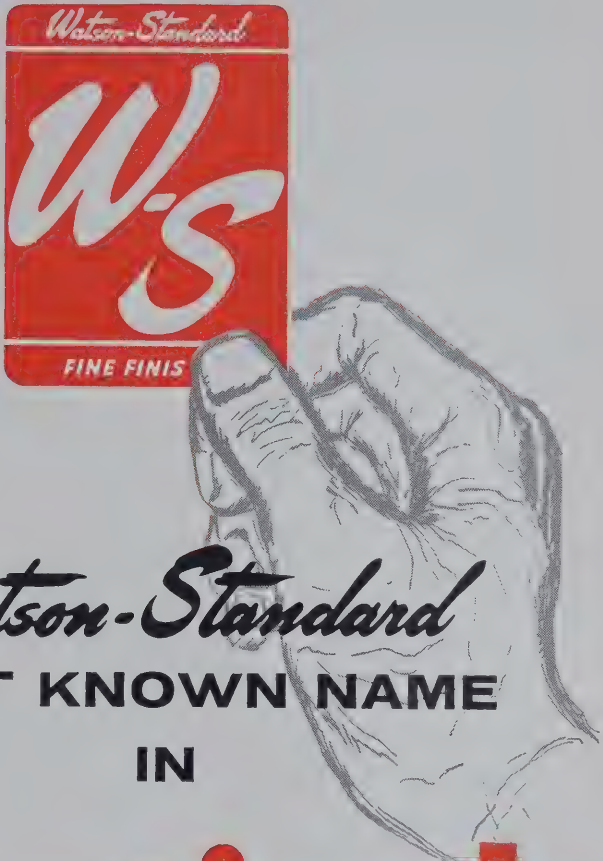

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Plastisols

Plastisols possess all the outstanding physical and chemical properties associated with polyvinyl chloride resins and are *individually formulated* to specific requirements of a wide variety of end uses. They are adaptable to many application methods—spray, dip, casting, rotational or slush molding, spread and roller coating, or troweling.

Watson-Standard's long experience in making special plastisol formulas is available to you through our laboratory and field technicians. Let us show you how plastisols can solve your problems.

Watson-Standard Co.

225 Galveston Avenue Pittsburgh 30, Pa.

PLASTICS · INDUSTRIAL FINISHES · CHEMICALS

Sandwiches: Part 1: Skins and facings

The structural sandwich panel consists of three or more layers of material bonded together so they act as a unit. The thin, outer layers, or skins, are of dense, strong material and bear most of the load imposed upon the panel.

Skin materials

Relatively few plastics are used in their unmodified state as facings for structural sandwiches; usually they are reinforced with some other material, such as sheet stock or fiber.

High-pressure laminates employed in building are almost entirely based upon a high strength paper, such as kraft, impregnated with a phenol formaldehyde resin and pressed under high temperatures and pressures into a hard, dense, strong, homogeneous sheet. The product will be dark brown in color; however, dark-hued pigments can be added. Also, the phenol paper backing can be faced with decorative sheet, which is in turn impregnated and overlaid with melamine formaldehyde to provide the familiar high-pressure decorative laminate widely employed in building.

Paper-based laminates will absorb some moisture but are resistant to decay. They do not burn readily, but will char and burn when exposed to fire. They can tolerate temperatures in the vicinity of 250° F. for indefinite periods of time. Strength properties depend largely upon the type of paper filling and the ratio of filling to resin employed. Modulus of elasticity is approximately 1,800,000 p.s.i. lengthwise and about 1,300,000 p.s.i. cross-wise. Tensile strength is about 20,000 p.s.i. in the lengthwise direction and approximately 16,000 p.s.i. cross-wise. Flexural and compressive strengths run somewhat higher. Phenolics show some surface degradation, color change, and loss of gloss upon exposure to weather.

Reinforced plastics used as sandwich skins most commonly consist of fibrous glass reinforced with polyester or epoxy resin. Of the two, the polyesters are by far the most extensively employed. The "straight" polyesters begin as liquids of viscosities varying from thin as water to thick as sirup and they harden by the addition of catalysts and hardeners at room temperatures. Their rate of hardening is accelerated as the temperature increases. However, the straight polyesters will burn (although not rapidly under most conditions) and if increased resistance to flame is required, the chlorinated polyesters can be employed. These are self-extinguishing, although they do not have as good weathering characteristics. Modifications of the straight polyesters (e.g., those incorporating acrylic resins) are appearing which show weathering properties superior to the straight and chlorinated types of polyesters. In order to obtain a good bond between the polyester resin and the reinforcing fiber such as glass, it is generally necessary to treat glass with a finishing material to enhance the polyester-fiber bond.

Epoxy resins form an inherently strong and tenacious bond to glass fibers. Although more expensive and trickier to handle than the polyesters, they provide strong reinforced plastics materials and are of growing importance in the field.

The reinforcing materials most commonly consist of fibrous glass in the form of mats of randomly distributed chopped glass filaments or in the form of woven fabrics in a wide variety of weights and weaves. For a general-purpose, low-cost reinforced plastics material, the mat materials are used. When maximum strength and stiffness are required, the woven fabrics are used, or layers of fibers are laid down parallel to each other in a unidirectional format, with individual layers oriented in arbitrary directions with respect to each other. Especially when unidirectional filaments are employed, strengths well in excess of those obtained with many high strength steels are available. Fillers may be employed to reduce light transmission or to increase resistance to weathering. Color may be imparted in the form of dyes or pigments; but for maximum permanence the most durable pigments should be employed.

Other fibers than glass may be and are employed to some extent as a reinforcing agent. Among the natural fibers are jute, hemp, sisal, and cotton; among the synthetic fibers used are nylon, polyester, etc.

The recent development of flake glass as a reinforcing material may markedly increase resistance to combustion; however, at the present, the strength characteristics of the glass flake laminates fall below those with fiber reinforcements.

Although the reinforced plastics can be and are employed by themselves as facings in structural sandwiches, they are frequently combined with a backup sheet such as plywood, metal, or cement-asbestos board for economy.

Polyvinyl chloride, in unplasticized, rigid sheet form has fairly good rigidity and strength properties for sandwiches, but is used essentially for a tough decorative coating over a more rigid backup sheet.

Acrylics stand up well when exposed to weather, though the clear plastic may show slight yellowing after prolonged exposure to sunlight. The material is highly impermeable to moisture and is dimensionally stable. It has a slow burning rate. The heat-distortion temperature can be as high as 200° F. It is about one-third as stiff as structural lumber, with a modulus of elasticity of 450,000 p.s.i. However, it is comparable in bending strength to wood, having compressive yield stresses as high as 10,000 p.s.i.

For Part 2 of Sandwich Constructions, covering cores to be used, see the article on p. 499. For applications, see p. 456.

CONDENSED FROM SECTIONS APPEARING IN "BUILDING WITH PLASTIC STRUCTURAL SANDWICH PANELS." A STUDY PREPARED BY MASS. INST. OF TECH., DEPT. OF ARCHITECTURE, IN ASSOC. WITH THE PLASTICS DIV., MONSANTO CHEMICAL CO.

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LUCITE®
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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Properties, characteristics and applications of

Du Pont Engineering Materials

Du Pont's problem-solving

Here at a glance are the outstanding qualities of four versatile plastic engineering materials from Du Pont, and some of the major applications in which each resin has solved a product or pro-

DELRIN®

ACETAL RESIN

The newest addition to Du Pont's family of plastic engineering materials, "Delrin" acetal resin, is a highly crystalline, stable form of polymerized formaldehyde. This completely new material offers you metal-like mechanical properties, such as a high degree of strength and rigidity, as well as others that metals do not possess. It retains its unusual properties under a wide range of service conditions. It is readily processed on conventional thermoplastic equipment. Over three years of pre-commercial field testing have already established its performance and production advantages in such applications as valve parts, instrument clusters, aerosol containers, industrial components, plumbing fixtures, clothing fitments and many others.

LUCITE®

ACRYLIC RESINS

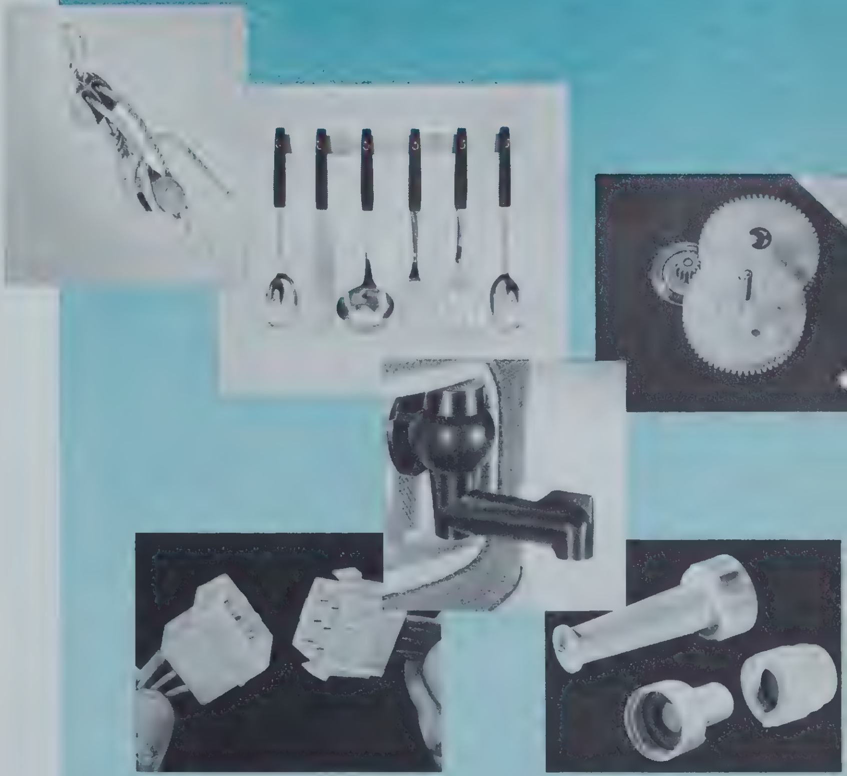
LUCITE is the registered trademark for Du Pont's acrylic resins. It has outstanding optical characteristics, outdoor stability, high strength, lightness in weight, intrinsic colorability. These outstanding characteristics have led to wide applications of LUCITE in architecture, signs, displays and lighting. Because LUCITE is extraordinarily strong and capable of being economically injection-molded to close tolerances, clear LUCITE is used as optical-lens material. Its gem-like colors make it ideal for taillight lenses, parking lights; for decorative emblems or parts for appliances; for specialty packaging and jewelry applications. It is available in a wide range of molding powders in a variety of colors and also available for extrusion.

duction problem. On the following pages you will find more specific data on each of these materials, to help you evaluate and specify the resin that best meets your needs.

ALATHON®

POLYETHYLENE RESINS

ALATHON is the registered trademark for Du Pont's family of polyethylene resins. It is easily formed in thin sections, unaffected by mineral acids and most organic solvents, and has excellent dielectric properties at all frequencies. By controlling the molecular structure during manufacture, Du Pont provides a wide variety of formulations of ALATHON, each tailored to meet specific needs. There are resins which will produce tough, transparent film, for such uses as packaging; others are engineered especially for use in making pipe, bottles, housewares, coating of various substrates, or wire and cable insulations.



ZYTEL®

NYLON RESINS

Du Pont's versatile group of durable polymeric amides, ZYTEL nylon resins, are noted for extreme toughness, abrasion resistance and strength. These properties, together with ease of fabrication and low coefficient of friction, make ZYTEL an effective material for cams, shafts, worm gears, often for unlubricated use. It has excellent flexibility at temperatures as low as -40°F., and is available in heat-stabilized grades. The dielectric strength of ZYTEL adapts it to such applications as injection-molded coil forms for electric equipment and other insulation uses at commercial power frequencies. It is available from processors in easily machined rod and stock forms, and in a tough, sparkling film for packaging applications.

DELRIN®

ACETAL RESIN

DELRIN acetal resin features high dimensional stability, tensile strength and flexural modulus, combined with excellent resilience and toughness. DELRIN is unusual in that it retains these properties under conditions of elevated temperature and humidity, during extended time under stress or during exposure to most solvents. It also has good abrasion resistance and a low coefficient of friction (evidences no "slip-stick"). DELRIN is available in a broad range of designer-selected colors.

Typical applications...

Appliance and automotive handles and other accessories of DELRIN are strong and can be economically mass-produced. Aerosol containers of DELRIN are lightweight, tough and virtually unaffected by most organic solvents. An instrument cluster of DELRIN weighs one-fifth its zinc counterpart; requires little, if any, finishing. "Squirrel-cage" blowers, gears and hardware parts of DELRIN are easily molded in integral colors. Strong, tough zippers of DELRIN resist heat, body oils and perspiration. Rust-free plumbing fixtures are unaffected by temperature extremes.

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LUCITE®
ALATHON®
ZYTEL®

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ALATHON

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TYPICAL PROPERTIES[1]

PROPERTY		ASTM NO.	AVERAGE VALUES FOR "DELRIN" 500X	150X
Elongation	−68°F.	D638	13%	38%
	73°F.	D638	15%	75%
	158°F.	D638	330%	460%
Impact strength Izod	−40°F.	D256	1.2 ft.lb./in.	1.8 ft.lb./in.
	73°F.	D256	1.4 ft.lb./in.	2.3 ft.lb./in.
Tensile strength and yield point	−68°F.	D638	14,700 psi	
	73°F.	D638	10,000 psi	
	158°F.	D638	7,500 psi	
Compressive stress at 1% deformation		D695	5,200 psi	
at 10% deformation			18,000 psi	
Flexural modulus	73°F.	D790	410,000 psi	
	170°F.	D790	190,000 psi	
	250°F.	D790	90,000 psi	
	100% RH 73°F.	D790	360,000 psi	
Flexural strength		D790	14,100 psi	
Shear strength		D732	9,510 psi	
Heat distortion temperature	264 psi	D648	212°F.	
	66 psi	D648	338°F.	
Fatigue endurance limit, 50 to 100% RH 70°F.			5,000 psi	
100% RH 150°F.			3,000 psi	
Water absorption, 24 hours immersion		D570	0.12%	
equilibrium, 50% RH		D570	0.2%	
equilibrium, immersion, 77°F.			0.9%	
Specific gravity		D792	1.425	
Rockwell hardness		D785	M94, R120	
Flammability		D635	1.1 in./min.	
Melting point (crystalline)			347°F.	
Flow temperature		D569	363°F.	
Deformation under load (2,000 psi at 122°F.)		D621	0.5%	
Coefficient of linear thermal expansion		D696	4.5×10^{-5} per °F.	
Taber abrasion (1000 gm. load, CS-17 wheel)		D1044	20 mg/1000 cycles	
Thermal conductivity			1.6 BTU/hr./sq. ft./°F./in.	
Specific heat			0.35 BTU/lb./°F.	
Modulus of rigidity			178,000 psi	
Poisson's ratio			0.35	
Dielectric constant, 73°F., 10^2-10^5 cps		D150	3.7	
Dissipation factor, 73°F., 10^2-10^5 cps		D150	.004	
Dielectric strength, short time		D149	500 V/mil	
Volume resistivity		D257	6×10^{14} ohm/cm	
Resistivity		D257	2×10^{13} ohm	
Arc resistance		D495	129 seconds (burns)	

Permeability:

	P factor at 73°F.
Water	1.9
Ethanol	0.2
Freon® 12-114 (20/80)	<0.2
Methyl salicylate	0.3

(gms loss / 24 hrs / 100 in^2 area / mil thickness. Determined on bottles with 35-50 mil wall thickness.)

Resistance to organics:

	Room Temp.	122° F.
CCl_4	1.2	5.7
Toluene	2.6	2.8
Acetone	4.9	2.6
Alcohol	2.2	1.9
Ethyl acetate	2.7	2.9

(% wgt. gain—12 mo. total immersion. Vol. change proportional to wgt. change.)

Fabrication . . .

DELRIN acetal resin is best suited to fabrication by injection molding and blow molding on standard equipment, running at economical output rates. DELRIN also has been extruded into various shapes and sizes using conventional screw extrusion machines. Welding techniques and mechanical fastenings have proved very practical in joining DELRIN. Hot-plate, induction, resistance-wire, inert-gas welding, as well as frictional or spin welding, give strong joints. DELRIN will accept and hold self-tapping screws or press-fit fasteners. Molded surface effects, painting and vacuum metalizing are also possible. DELRIN possesses excellent machinability for operations such as drilling, lathe turning, milling and automatic screw machine operations.

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(1) These values are representative of those obtained under standard ASTM conditions and should not be used to design parts which function under different conditions. Since they are average values, they should not be used as minimums for material specifications.

LUCITE®

ACRYLIC RESINS

LUCITE weighs about one-third as much as glass and has relatively high impact strength, even at low temperatures. Its thermal conductivity is low, about that of rubber. Used mainly for its superior clarity and optical properties, LUCITE transmits 92% of the light striking it. The clarity is not diminished by age, sunlight or moisture. When its surface is highly polished, LUCITE has the ability to pipe light around angles as acute as 42° or curves with radii three times or more the thickness of the material. Unsual "edge-lighting" effects are also possible. Laminates made from the new LUCITE acrylic sirup feature superior weatherability, light diffusion and resistance to impact and abrasion.

Typical applications . . .

Control panels molded of LUCITE retain their sparkle for the life of the appliance. Other appliances, such as window fans, use the light-piping abilities of LUCITE to illuminate controls. Beautiful automotive parts resist shattering and are easily cleaned. Lenses of LUCITE for slide viewers and similar optical uses are virtually unbreakable. For chemical pumps and other industrial applications, LUCITE can be molded to close tolerances. Colorful building panels of reinforced LUCITE acrylic sirup feature beauty that *lasts*.

TYPICAL PROPERTIES[1]

	property	*units*	*methods*	*molded 40 and 140*	*molded 29 and 129*	*molded 30 and 130*
mechanical	Tensile strength, 73°F.	LB./SQ. IN.	D638-56T	10,600	10,000	9,500
	Elongation, 73°F.	%	D638-56T	3-5	3-5	3-5
	Modulus of elasticity, 73°F.	LB./SQ. IN.	D638-56T	400,000	400,000	400,000
	Shear strength	LB./SQ. IN.	D732-46	9,400	9,000	7,500
	Impact strength, Izod, 73°F.	FT.-LB./IN.	D256-56	0.3	0.3	0.3
	Stiffness, 73°F.	LB./SQ. IN.	D747-58T	430,000	410,000	340,000
	Flexural strength, 73°F.	LB./SQ. IN.	D790-49T	16,500	15,500	14,500
	Compressive stress at 1% deformation	LB./SQ. IN.	D695-54	4,800	4,600	4,600
	Hardness, Rockwell		D785-51	M103	M95	M88
thermal	Coefficient of linear thermal expansion per °F.		D696-44	3×10^{-5}	4×10^{-5}	4×10^{-5}
	Thermal conductivity (2)	B.T.U./hr./sq. ft./ °F./in.		1.4	1.4	1.4
	Specific heat (0-100° 6 range)			0.35	0.35	0.35
	Deformation under load, 122°F., 2000 lb./sq. in.	%	D621-51	0.4	0.7	
	Heat-distortion temperature, 264 lb./sq. in.	°F.	D648-56	202	180	166
	66 lb./sq. in.	°F.	D648-56	216	190	175
electrical	Dielectric strength, short time (1/8 in.)	V/MIL.	D149-55T	400	400	400
	step-by-step (1/8 in.)	V/MIL.	D149-55T	370	370	370
	Volume resistivity	OHM-CM.	D257-57T	$> 10^{15}$	$> 10^{14}$	$> 10^{14}$
	Dielectric constant, 60 cycles		D150-54T	3.5	3.9	3.9
	10^6 cycles		D150-54T	2.8	2.7	2.8
	Power factor, 60 cycles		D150-54T	0.055	0.042	0.042
	10^6 cycles		D150-54T	0.009	0.011	0.012
optical	Index of refraction	n_D	D542-50	1.49	1.49	1.49
	Luminous transmittance, illuminant C, 1/8 in.	%	D791-54	> 92	> 92	> 92
	Transmittance at 4500 A°, 1/8 in.	%	D791-54	90	90	90
	Haze	%	D1003-52	< 3	< 3	< 3
miscellaneous	Water absorption (24 hrs.)	%	D570-54T	0.3	0.3	0.3
	Flammability	IN./MIN.	D635-56T	1.2	1.2	1.2
	Specific gravity		D792-50	1.18	1.18	1.18
	Mold shrinkage	IN./IN.	D955-51	0.002-0.006	0.002-0.006	0.002-0.006
	Compression ratio		D392-38	1.8-2.2	1.8-2.2	1.8-2.2
	Resistance to weathering			Excellent	Excellent	Excellent
	Basic color			Water white transparent	Water white transparent	Water white transparent
	Resistant to			Water, weak acids, weak alkalies	Water, weak acids, weak alkalies	Water, weak acids, weak alkalies
	Not resistant to			Lower ketones, esters, aromatic hydrocarbons, strong acids, strong alkalies	Lower ketones, esters, aromatic hydrocarbons, strong acids, strong alkalies	Lower ketones, esters, aromatic hydrocarbons, strong acids, strong alkalies

Formulations and fabrication . . .

LUCITE is available in a range of molding powders with a variety of molding characteristics and properties and a broad selection of transparent, translucent and opaque colors. Powders are granular, 1/8″ cubes for injection molding, or minute, spherical granules for compression molding. There are also resins for extrusion and LUCITE acrylic sirup, a low-pressure laminating resin available in a range of colors.

Molding powders of LUCITE may be fabricated either by injection molding or compression molding or by extrusion. Molded LUCITE may be shaped with woodworking equipment in much the same fashion as wood or soft metal. Pieces may be joined either by cementing, heat or spin welding. LUCITE may be decorated with paint, stains, silk-screen designs or by sand blasting, carving or etching. To obtain stable colors, certain pigments or dyes may be added before molding. LUCITE acrylic sirup is hardened by vinyl-type polymerization. It is reinforced with glass or organic fibers.

Footnotes: Tests have been performed by ASTM methods unless otherwise indicated. Data shown are average values and should not be used for specifications.

(1) Other compositions of "Lucite" are available for special requirements. The types shown here are the most widely used at the present. The properties shown here apply to standard compositions.

(2) Thermal conductivity measured by Cenco-Fitch apparatus.

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ALATHON®

POLYETHYLENE RESINS

This white, translucent resin is essentially odorless and tasteless. Its water absorption and rate of water-vapor transmission are low. ALATHON is inert to most solvents and chemicals (including food acids) at room temperatures, and to most chemical reagents. It has excellent dielectric characteristics because of its non-polar molecular structure. Resistivity is high, power-loss factor and inductive capacity are low. ALATHON remains flexible at low temperatures, will not become brittle at temperatures as low as -95°F.

Typical applications . . .

Coatings on convenient heat-and-serve packages make possible strong heat seals that stand up under extremes of temperature. Because it is chemical-resistant, ALATHON makes snap-back squeeze bottles that are unaffected by contents. Moisture-resistant film of ALATHON, combined with rust-inhibiting discs, opens new possibilities for packaging delicate metal parts. Insulation and jacketing of ALATHON on underwater cables provide protection from moisture plus dielectric strength. Light, flexible pipe of ALATHON Super 25 has superior burst strength. A coating of ALATHON on milk cartons prevents leakage, won't flake off.

Formulations and fabrication . . .

ALATHON is available in a wide range of formulations, each tailored for specific applications. It is supplied to coaters, extruders and molders in ⅛″ cubes. Molding powders of ALATHON are fabricated by any of the standard techniques—injection molding, compression molding or by extrusion. ALATHON may be applied to paper, cloth or other flexible materials by extrusion coating. Sheeting of ALATHON may be vacuum-formed. Solid shapes of ALATHON may be machined from bar stock, rod or tube, with the standard tools and techniques used in working soft metals. Separate pieces are joined by heat welding or spin welding.

ELRIN® | LUCITE® | ALATHON® | ZYTEL®

I am interested in evaluating these materials for______________________________

NAME______________________________POSITION____________________

COMPANY____

STREET____

CITY____________________________STATE______________________

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WILMINGTON 98, DELAWARE

TYPICAL PROPERTIES[1]

	property	*units*	*methods*	*molded 10* (2)
	Tensile strength, −70°F.	LB./SQ. IN.	D638-56T	4,750 (8)
	73°F.	LB./SQ. IN.	D638-56T	1,900 (8)
	170°F.	LB./SQ. IN.	D638-56T	850 (8)
	Elongation, −70°F.	%	D638-56T	60 (8)
mechanical	73°F.	%	D638-56T	600 (8)
	170°F.	%	D638-56T	600 (8)
	Modulus of elasticity, 73°F.	LB./SQ. IN.	D638-56T	35,000
	Shear strength	LB./SQ. IN.	D732-46	2,750
	Impact strength, Izod, −40°F.	FT.-LB./IN.	D256-56	0.8
	73°F.	FT.-LB./IN.	D256-56	did not break
	Stiffness, 73°F.	LB./SQ. IN.	D747-58T	27,000
	Hardness, Rockwell		D785-51	C81, D48 (3)
	Flow temperature	°F.	D569-48	201 (7)
	Coefficient of linear thermal expansion per °F.		D696-44	9×10^{-5}
thermal	Thermal conductivity (4)	B.T.U./hr./sq. ft./ °F./in.		1.7
	Specific heat (0-100° 6 range)			0.55
	Deformation under load, 122°F., 2000 lb./sq. in.	%	D621-51	0.6 (5)
	Heat-distortion temperature, 66 lb./sq. in.	°F.	D648-56	121
	Dielectric strength, short time (1/8 in.)	V/MIL.	D149-55T	460
	step-by-step (1/8 in.)	V/MIL.	D149-55T	420
	Volume resistivity	OHM-CM.	D257-57T	$> 10^{15}$
	Dielectric constant, 60 cycles		D150-54T	2.3
electrical	10^3 cycles		D150-54T	2.3
	10^6 cycles		D150-54T	2.3
	10^8 cycles		D150-54T	2.3
	Power factor, 60 cycles		D150-54T	<0.0005
	10^3 cycles		D150-54T	< 0.005
	10^6 cycles		D150-54T	< 0.005
	10^8 cycles		D150-54T	< 0.005
optical	Index of refraction	n_D	D542-50	1.51
	Water absorption (24 hrs.)	%	D570-54T	0.014
	Flammability	IN./MIN.	D635-56T	0.94
	Specific gravity		D792-50	0.92
miscellaneous	Mold shrinkage	IN./IN.	D955-51	0.02-0.05
	Compression ratio		D392-38	2.1-3.6
	Resistance to weathering			Fair (6)
	Basic color			White translucent
	Resistant to			Water, acids, alkalies, oxygenated solvents
	Not resistant to			Chlorinated solvents, aliphatic and aromatic hydrocarbons

Footnotes: Tests have been performed by ASTM methods unless otherwise indicated. Data shown are average values and should not be used for specifications.

(1) Other compositions of "Alathon" are available for special requirements. The type shown here is the most widely used at the present. The properties shown here apply to standard compositions.

(2) "Alathon" 5 differs from "Alathon" 10 in the fact that the former contains an anti-oxidant.

(3) Hardness of "Alathon" determined by Shore durometer.

(4) Thermal conductivity measured by Cenco-Fitch apparatus.

(5) Deformation under load for "Alathon" determined at 100 lb./sq. in. (standard for non-rigid plastics).

(6) The outdoor durability of black-pigmented "Alathon" is excellent.

(7) Softening point, Vicat.

(8) ASTM method D412-51T, diec.

Packaging with ALATHON

There is an ALATHON polyethylene resin specifically designed for every packaging need, its molecular structure carefully controlled during manufacture to give it certain characteristics required in specific end uses. For example, ALATHON 20 has high stress-crack resistance and impermeability. ALATHON 16 has excellent adhesion and good draw rate for paper coating. And so on through the various applications of film, molded products and coatings.

COMPOSITIONS OF "ALATHON"	BASIC CHARACTERISTICS		OUTSTANDING PROPERTIES AND RECOMMENDED APPLICATIONS
	MELT INDEX	DENSITY	
10	2.1	0.923	Very good transparency, stiffness and impermeability • Film, molded containers, bottles
14	1.8	0.914	Good toughness and flexibility. Shrinkable film • Film, molded articles
16	4.0	0.923	Outstanding coating characteristics, good impermeability and grease resistance • Coatings
17	20.0	0.923	Outstanding gloss and molding characteristics, very good impermeability and stiffness • Molded containers, closures
20	2.1	0.920	Outstanding resistance to environmental stress cracking, good impermeability • Molded containers; blown bottles; closures
22	3.0	0.921	Very good toughness, good impermeability, stiffness and transparency • Molded containers, bottles
23A	3.4	0.921	Outstanding transparency and gloss, good impact strength • Film
31	0.6	0.930	Exceptional stiffness, gloss and resistance to environmental stress cracking • Thermoforming
34	3.0	0.930	Very high stiffness, sparkling clarity, high heat-distortion temperature • Film, blown bottles, coatings, molded containers
37	12.0	0.930	Outstanding impermeability, stiffness and gloss, very good molding characteristics (high flow, short cycle) • Molded containers

"A" refers to base resin with added slip.

ALATHON 10A, 16A and 34A are also available.

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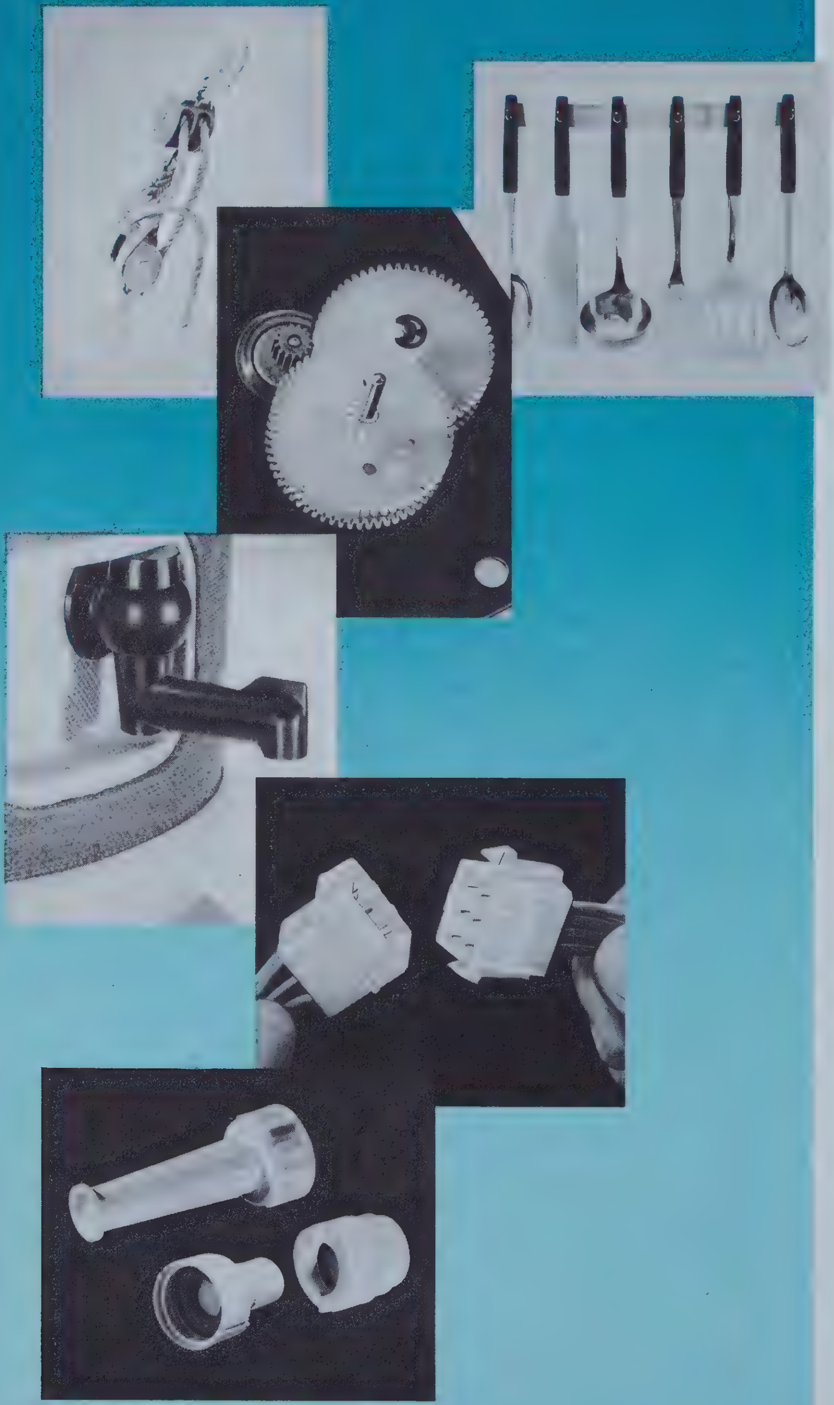
ZYTEL®

NYLON RESINS



ZYTEL nylon resins are tough and resilient, even at low temperatures (-40°F.). Heat-stabilized grades may be used for high-temperature operations in the neighborhood of 250°F. They require little or no lubrication. They resist abrasion. They are light in weight, and have good form stability. Dielectric properties are good at commercial power frequencies. They are unaffected by common solvents, alkalies, dilute mineral acids and most organic acids. They offer good color stability and attractive texture.

Typical applications . . .

Blocks of ZYTEL are strong, light in weight and require little or no lubrication. Unbreakable kitchenware handles of ZYTEL are attractive and easily colored. Clock gears and other precision parts of ZYTEL are molded to close tolerances and have strength in thin sections. Fold-away picnic-jug spigot of ZYTEL operates smoothly, resists heat. Compact multiple connectors of ZYTEL have good dielectric properties. Inexpensive nozzle and snap-on hose couplings are tough and resist garden chemicals.

Formulations and fabrication . . .

Various formulations of ZYTEL nylon resins are available. Rod and stock forms of ZYTEL are readily available from processors, and may be easily machined. ZYTEL 42 has a viscosity specially tailored for extrusion and makes a tough, sparkling packaging film. Coatings and laminations are also possible with this resin. ZYTEL nylon resins are available in a variety of colors. Parts of ZYTEL may also be colored by immersing the parts in a boiling solution of dyes, such as those used for dyeing of household fabrics. ZYTEL 105 is a weather-resistant, black nylon resin specially developed for outdoor use.

ZYTEL nylon resins may be extruded or injection-molded either as solid parts or around metal inserts. ZYTEL can be applied as jacketing or insulation to wires either directly or over other primary insulating materials. Stock shapes may be easily machined with cutting tools of high-speed steel (ground to produce minimum drag). Where dimensional stability is essential, machined parts should be stress-relieved. The spin-welding technique is also useful for fabrication of ZYTEL.

TYPICAL PROPERTIES[1]

	property	units	methods	molded 101		molded 31		molded 63	molded 42	
				0.2% moisture	2.5% moisture	0.2% moisture	1.5% moisture	0.2% moisture	0.2% moisture	2.5% moisture
mechanical	Tensile strength, –70°F.	LB./SQ. IN.	D638-56T	15,700 (2)	13,500 (2)	12,000	12,100 (2)	13,000 (2)		16,100 (2)
	73°F.	LB./SQ. IN.	D638-56T	11,800	11,200	8,500	7,100	7,400	12,600	8,600
	170°F.	LB./SQ. IN.	D638-56T	9,000		5,300		5,000	8,500	
	Elongation, –70°F.	%	D638-56T	20 (2)	20 (2)	20	30 (2)	8.0 (2)		35 (2)
	73°F.	%	D638-56T	60	300	85	320	300	90	240
	170°F.	%	D638-56T	340		300		400	155	
	Modulus of elasticity, 73°F.	LB./SQ. IN.	D638-56T	410,000	175,000	280,000	160,000	38,000	410,000	175,000
	Shear strength	LB./SQ. IN.	D732-46	9,600		8,400		5,700	5,600	
	Impact strength, Izod, –40°F.	FT.-LB./IN.	D256-56	0.6	0.45	0.6		0.9		
	73°F.	FT.-LB./IN.	D256-56	0.9	2.0	0.6	1.6	> 16	1.3	
	Flexural strength, 73°F.	LB./SQ. IN.	D790-49T	13,800 (4)		8,000 (4)			13,800 (4)	
	Compressive stress at 1% deformation	LB./SQ. IN.	D695-54	4,900		3,000		800	4,900	
	Hardness, Rockwell		D785-51	M79, R118	M59, R108	R111		R83	R118	
thermal	Coefficient of linear thermal expansion per °F.		D696-44	5.5 x 10^{-5}		5.5 x 10^{-5}		8.2 x 10^{-5}	5.5 x 10^{-5}	
	Thermal conductivity (3)	B.T.U./hr./sq. ft./ °F./in.		1.7		1.5		1.9	1.7	
	Specific heat (0-100° 6 range)			0.3-0.5		0.3-0.5		0.4	0.3-0.5	
	Deformation under load, 122°F., 2000 lb./sq. in.	%	D621-51	1.4		4.2		20	1.4	
	Heat-distortion temperature, 264 lb./sq. in.	°F.	D648-56	150		135			150	
	66 lb./sq. in.	°F.	D648-56	360		300		100	360	
electrical	Dielectric strength, short time (1/8 in.)	V/MIL.	D149-55T	385		470		420	385	
	step-by-step (1/8 in.)	V/MIL.	D149-55T	340		410		400	340	
	Volume resistivity	OHM-CM.	D257-57T	4.5 x 10^{13}		4 x 10^{14}		5 x 10^{13}		
	Dielectric constant, 60 cycles		D150-54T	4.0	7.6	3.9		4.9	4.0	7.6
	10^3 cycles		D150-54T	3.9	6.4	3.6		4.6	3.9	6.4
	10^6 cycles		D150-54T	3.6	3.6	3.5			3.6	3.6
	Power factor, 60 cycles		D150-54T	0.014		0.04		0.19	0.014	
	10^3 cycles		D150-54T	0.02		0.04		0.18	0.02	
	10^6 cycles		D150-54T	0.04		0.03		0.14	0.04	
miscellaneous	Water absorption (24 hrs.)	%	D570-54T	1.5		0.4		2.0	1.5	
	Saturation		D570-57T	8		3.5		20	8	
	Flammability	IN./MIN.	D635-56T	self-extinguishing		self-extinguishing		self-extinguishing	self-extinguishing	
	Specific gravity		D792-50	1.14		1.09		1.08	1.14	
	Mold shrinkage	IN./IN.	D955-51	0.015		0.015				
	Compression ratio		D392-38	2.1		2.2		2.5	2.1	
	Resistance to weathering			Good		Good		Good	Good	
	Basic color			Light translucent		Translucent		Semitransparent	Light translucent	
	Resistant to			Esters, ketones, common solvents, alkalies, weak acids		Esters, ketones, common solvents, alkalies, weak acids		Esters, ketones, alkalies	Esters, ketones, common solvents, alkalies, weak acids	
	Not resistant to			Phenol, formic acid, concentrated mineral acids		Phenol, formic acid, concentrated mineral acids		Phenol, alcohols, formic acid, mineral acids	Phenol, formic acid concentrated mineral acids	

Footnotes: Tests have been performed by ASTM methods unless otherwise indicated. Data shown are average values and should not be used for specifications.

(1) Other compositions of "Zytel" are available for special requirements. The types shown here are the most widely used at the present. The properties shown here apply to standard compositions.

(2) Data at –40°F.

(3) Thermal conductivity measured by Cenco-Fitch apparatus.

(4) Maximum flexural stress during test.

DELRIN®

LUCITE®

ALATHON®

ZYTEL®

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PHENOLIC RESINS
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RCI

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Please send me full technical information on the use of RCI PLYOPHEN Phenolic Resins for the applications I have indicated above.

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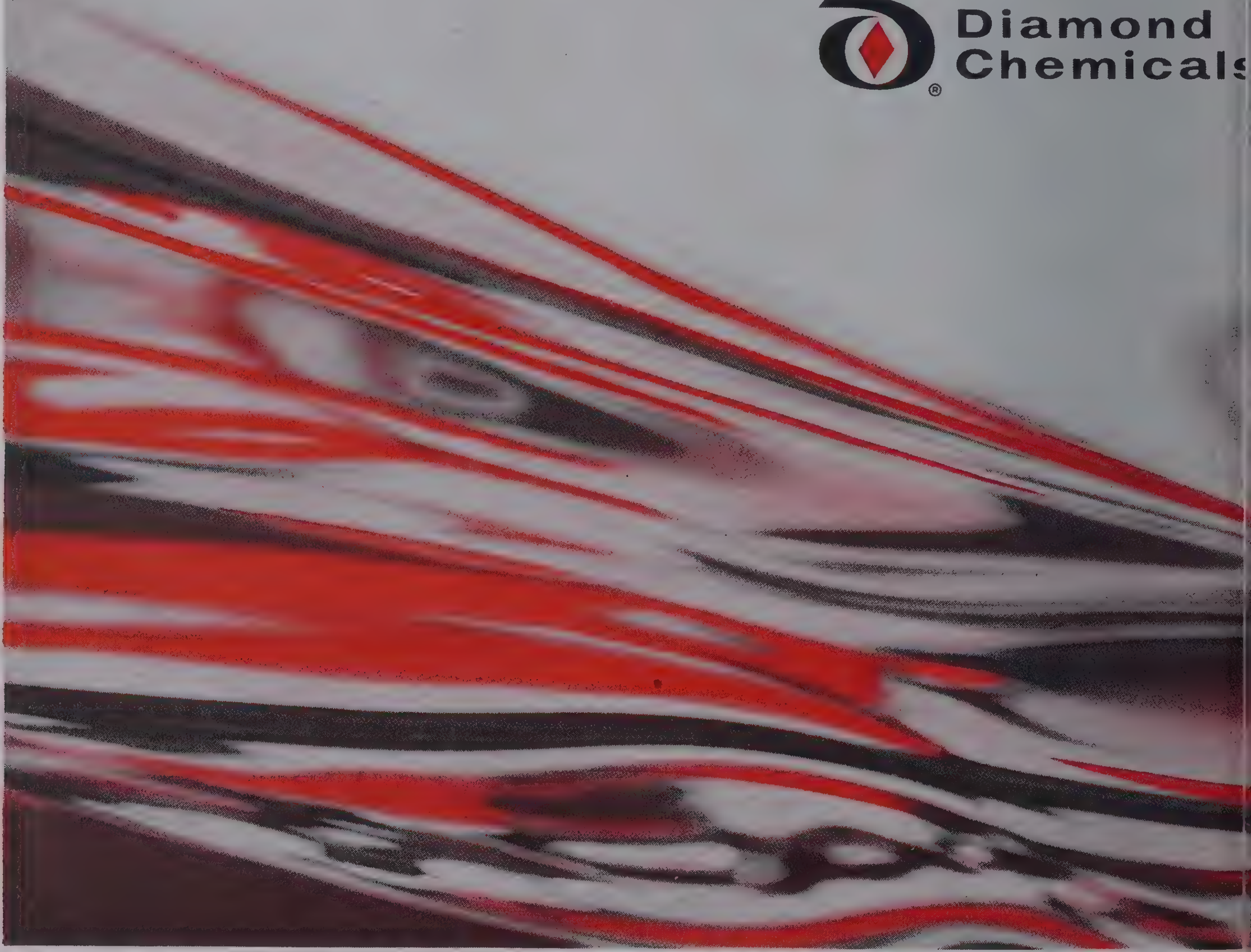
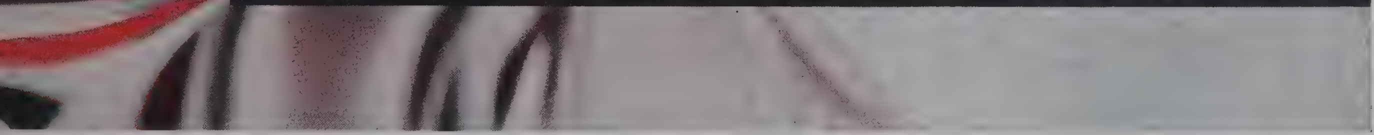


Resin	Specific Viscosity	Applications	Main Advantages
PVC-500	1.63	Dry blend extrusions. Calendered film and sheeting. Wire insulation.	Rapid plasticizer absorption. Clarity and freedom from gel particles. U.L. approved.
PVC-450	1.35	Dry blend extrusions. Calendered film and sheeting. Rigid applications. Wire insulation.	Rapid plasticizer absorption. Clarity and freedom from gel particles. U.L. approved.
PVC-60	1.63	Supported and unsupported calendered film and sheeting. Extrusion.	High monomeric and polymeric plasticizer absorption. Cold dry blends.
PVC-40	1.10	Calendering and molding. Semirigid sheeting.	High calender production rate. Excellent heat stability and good flow.
PVC-35	0.85	Base for high gloss injection molding compounds. Processing aid.	Excellent flow. Improves processing without sacrificing heat stability.
PVC-30	0.63	Processing aid in molding and calendering. Excellent modifier for copolymer formulations.	Reduces temperature requirements and shortens production cycles.
PVC-25	1.10	Designed for unplasticized applications. Injection molded items or calendered rigid film and sheet.	Good flow and superior heat stability. Can be handled in standard equipment.
PVC-70 (Paste resin)	1.80	Plastisols and organosols.	Combination of good low-shear and high-shear viscosity, clarity and aging.
CR-80 (Copolymer)	0.56	Records and rigid film.	High flow, low volatiles, good heat stability.
FCR (Copolymer)	0.61	Flooring.	Easy processing and high bulk density.
PVC-FG (Resins)	0.63- 1.35	Flooring.	Uniformity, good processability, clarity and heat stability.

A number of rigid and elastomeric compounds are also available for specific applications.



THE OUTSTANDING STABILITY OF

DAPON® RESIN

TO IMPROVE PRODUCT PERFORMANCE AND LOWER COSTS IN MOLDINGS AND LAMINATES

✓ Thermal Stability

DAPON resin molded parts exhibit outstanding stability under extreme conditions of exposure to heat and humidity. Under such conditions they do not crack or change shape. For example, after several months exposure to boiling water, DAPON resin molded cups show no degradation of any kind. DAPON resin molded parts are serviceable at temperatures up to 400-450°F. Higher temperature modifications of DAPON resins are currently under development.

✓ Dimensional Stability

DAPON resin exhibits almost no shrinkage during cure and no shrinkage following cure. The lack of post-mold shrinkage makes possible formation of complex matching parts with close tolerances and small or large metallic inserts without cracking.

✓ Chemical Stability

DAPON resin compounds are extremely resistant to acids, bases and organic solvents even at high temperatures, as well as to staining and color degradation.

✓ Electrical Stability

DAPON resin molded parts are noted for the retention of their excellent insulation resistance, dielectric strength, and arc resistance even after exposure to high humidity and to elevated temperatures. DAPON resin's unusual chemical stability insures absence of breakdown and attendant corrosion of metallic electronic components under the most severe conditions of use. DAPON resin is unmatched by any other plastic in this regard.

✓ Color Stability

DAPON resin can be compounded in pastel colors which exhibit greater color stability at elevated temperature than any other known colored plastics.

✓ For Help In Solving Your Problems

Write today for technical literature detailing properties, uses and methods of application for DAPON resin.

***DAPON** Resin is Food Machinery and Chemical Corporation's registered trade name for its brand of diallyl phthalate prepolymer. Names of compounders of DAPON resin molding powders are available on request.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Chemicals and Plastics Division

161 EAST 42ND STREET, NEW YORK 17, N. Y.

Looking for vinyl resins with "plus" properties?

Look to PLIOVIC by GOODYEAR

WANT TO IMPROVE THE AUDIO OF STEREO?

Pliovic has proved its ability to strengthen stereo record grooves and enhance tonal quality. It also improves compound "flow" during high-speed processing, reduces flash, makes possible more efficient production. Can it do the same for you?

NEED A CLEARLY SUPERIOR COMPOUND?

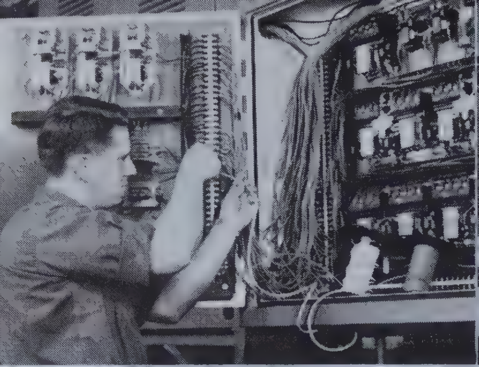
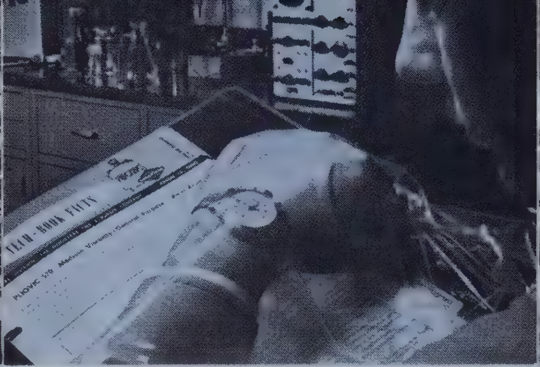
Pliovic is used in many applications where exceptional clarity and maximum flow at moderate temperatures are required—as in the molding of goggle frames. Ideal for calendered or extruded applications which call for critical processing and excellent transparency.

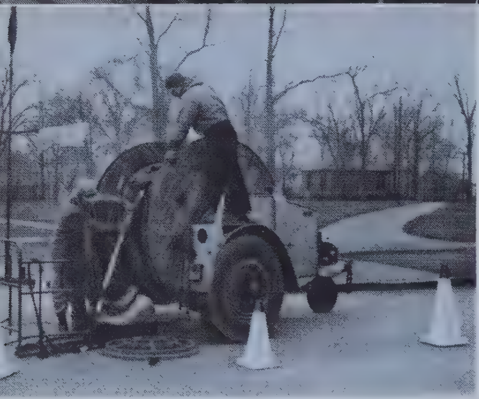
HOW ABOUT A FILM IN 3-D?

Careful compounding and processing of fluorescent pigments with Pliovic produced this strikingly different beach ball made of vinyl film. Pliovic processes readily at relatively low temperatures, minimizes the effects of heat degradation on both resin and pigment, embosses easily and sharply—and provides excellent heat-sealability.

Photos courtesy the following companies: Capitol Records, Inc., Hollywood, Calif., Harte & Co., Inc., New York, N.Y., and American Optical Company, Southbridge, Mass.

For more sales-building ideas with Pliovic—turn the page—



More resins in the
Pliovic family
with
more "plus"
values for you

Pliovic S50 – a low molecular weight straight PVC resin with the inherent toughness of PVC resins but with flow characteristics comparable to the copolymers. Now being used in stereo record compounds.

Pliovic S70 – a general purpose, medium viscosity PVC resin. Well suited for applications requiring maximum flow, sparkling clarity and moderate processing temperatures.

Pliovic AO–a copolymer PVC dispersion resin, available in three paste viscosity grades. In plastisol formulations, it offers gradual gel properties that begin at relatively low mold temperature.

Pliovic DB90V – a high molecular weight PVC dry blending resin. Provides free-flowing dry blends, uniform fluxing rate and smooth, homogeneous vinyl products.

Pliovic DB80V – offers the same quality features as DB90V, but has lower molecular weight. Can be fluxed at temperatures 5 to 10 degrees lower.

Pliovic EDB90V – a dry blending resin on the resin interchangeability list of Underwriters' Laboratories, Inc. This high-purity PVC flows freely, disperses readily – can be fed right into extrusion equipment.

Blends of Pliovic resins offer such advantages as: smaller concentrations of plasticizer, closer control of plastisol flow and fusion over a complete range of hardness.

More information and complete technical assistance on all Pliovic resins are yours for the asking. Simply call the Goodyear Chemical Division Field Office nearest you.

Goodyear Chemical Division Field Offices

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2755 Piedmont Road, N. E.
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Phone: Hillcrest 4-3900

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Phone: Michigan 2-8800

CLEVELAND, OHIO
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Phone: Clearwater 2-3000

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Phone: Walnut 1-7900

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Phone: Butler 9-3424

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P. O. Box 1678
Phone: Walnut 3-5541

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Phone: Raymond 3-3611

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418 Stinson Boulevard
Phone: Sterling 9-3551

NEW YORK, NEW YORK
400 Park Avenue
Phone: Plaza 1-6000

PHILADELPHIA, PENNSYLVANIA
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Phone: Baldwin 8-8500

PORTLAND, OREGON
2720 N. W. 35th Avenue
Phone: Capitol 6-2951

ST. LOUIS, MISSOURI
8544 Page Boulevard
Phone: Harrison 9-4000

SAN FRANCISCO, CALIFORNIA
1717 Harrison Street
P. O. Box 648
Phone: Underhill 1-3773

OR–WRITE TODAY for latest *Tech Book Bulletins* on Pliovic to
Goodyear, Chemical Division, Dept. K-9440, Akron 16, Ohio.

GOODYEAR
CHEMICAL DIVISION

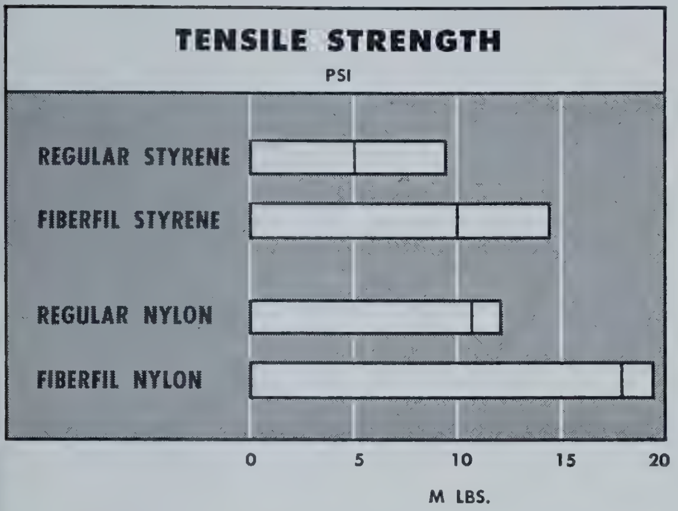
Pliovic–T.M. The Goodyear Tire & Rubber Company, Akron, Ohio

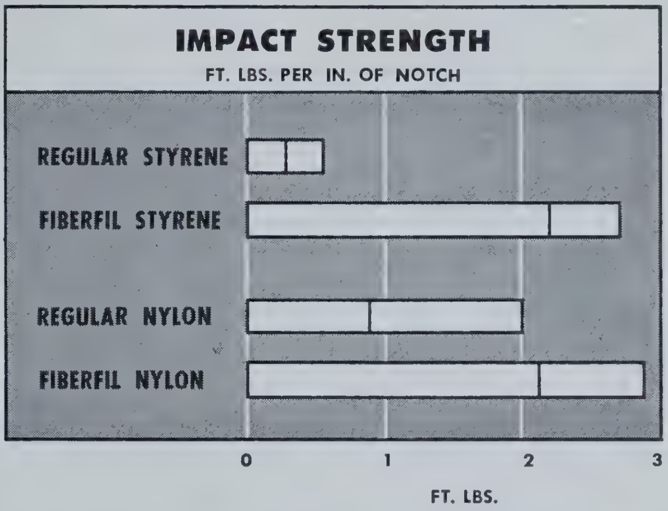
Photos courtesy of the following companies: Royal Electric Corporation, Pawtucket, R. I.; United Plastics & Development Company, Kent, Ohio; Akron Preform Mold Company, Cuyahoga Falls, Ohio; Bedminster Sound Corp., Belleville, N. J.

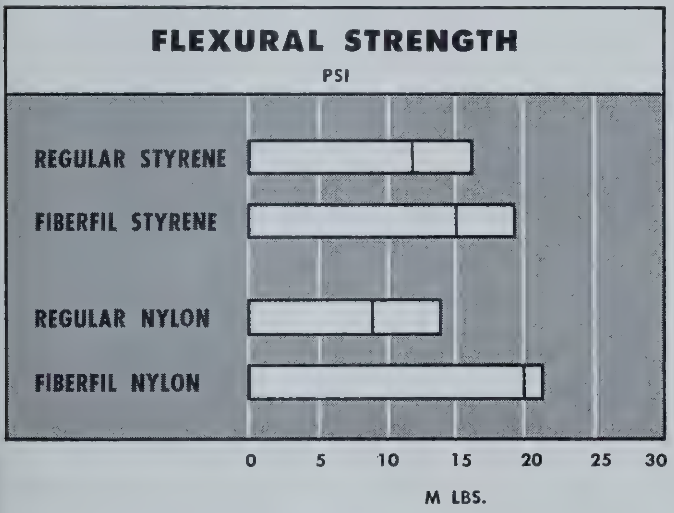
FIBERFIL

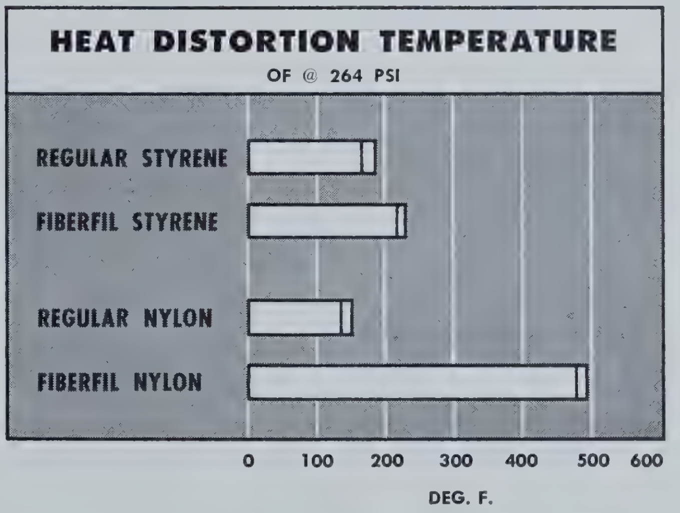
is outstanding in
4 KEY PROPERTIES

(double lines in each bar indicate minimum and maximum ranges)









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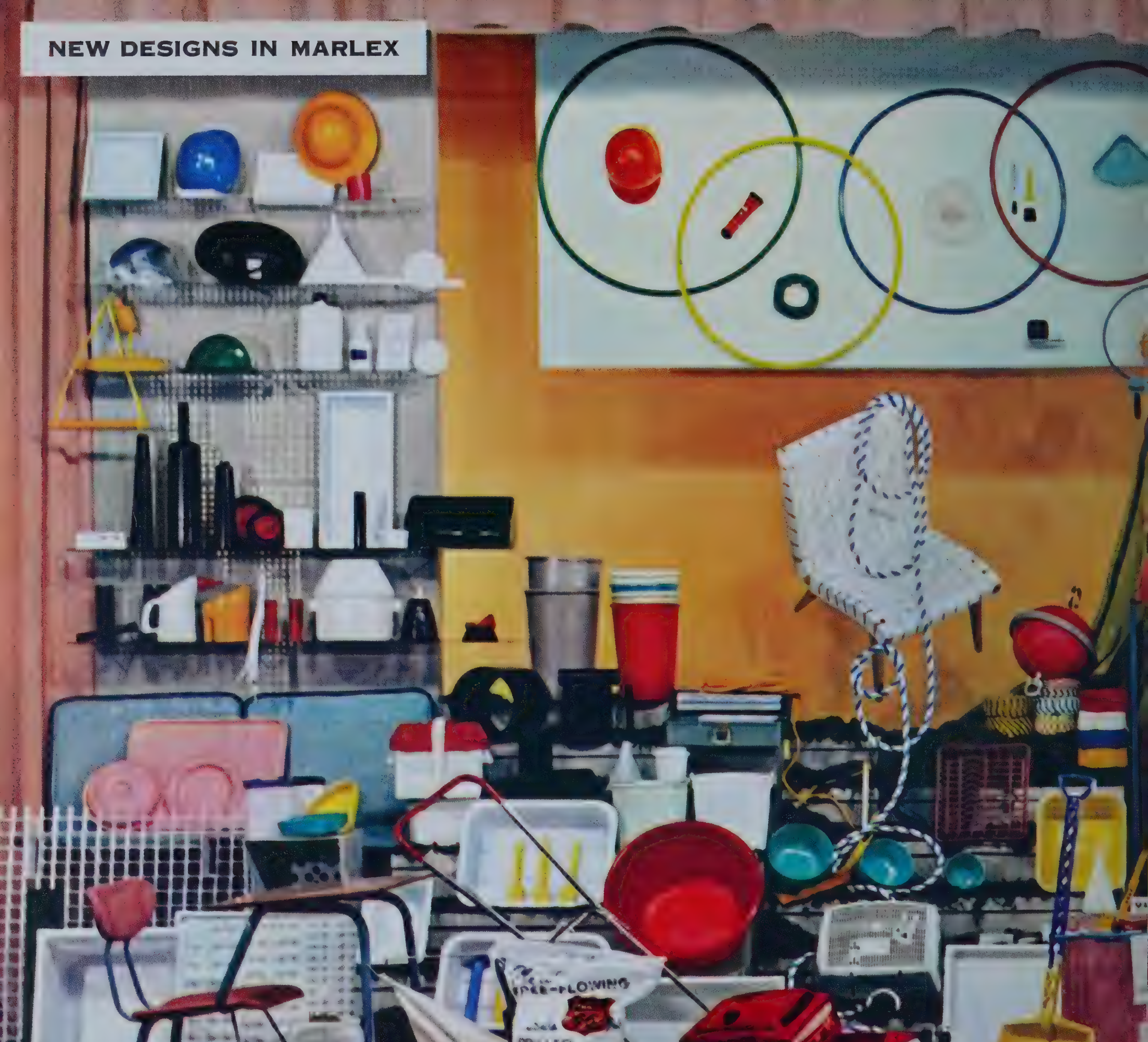

Now on the market! Hundreds of new products made with MARLEX*

Here is the latest display of commercially available products made with Marlex linear polyethylene. These new items range from tiny ball point pen parts to large housings for lawnmowers and TV sets . . . from thin, clear packaging film to heavy-duty bag material . . . from colorful fabrics to high-tensile rope that floats. Manufacturers are turning to Marlex because it is an economical material that can be precision molded, formed or extruded. And everyone recognizes the advantages of using Marlex for high-quality, yet inexpensive housewares and toys that are boilproof and virtually indestructible.

No other type of material serves so well and so economically in so many different applications. How can Marlex serve you?

*MARLEX is a trademark for Phillips family of olefin polymers

Write today for new, free MARLEX Brochure!

Phillips Chemical Company
Plastic Sales Inc., Bartlesville, Oklahoma

Gentlemen:

Please send me my free copy of your latest MARLEX Brochure.

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Polyflex cuts packaging costs up to 40%

Low Cost FDA-Approved* Polystyrene is Crystal-Clear, Non-Toxic, Odorless... Delivers more Packages Per Pound Than Cellophane and Acetate Films.

- will not wrinkle from moisture
- will not curl, shrink or embrittle
- can be vacuum and pressure formed
- extends shelf life indefinitely

Polyflex film and sheet, in gauges from 1 to 20 mils, is now available in quantity. It is machinable on conventional package equipment and heat-sealable for in-store wrapping and packaging. *Its low price and high yield per pound permit savings up to 40%, compared with other packaging films.*

Suggested Polyflex Uses

Bakery Goods • Meats • Poultry • Vending • Desserts • Frozen Foods • Fruits
Dairy Products • Ice Cream • Sandwiches • Produce • Salads • Jams & Jellies • Seafoods

POLYFLEX PROPERTIES

GENERAL AND MECHANICAL	
Yield (theoretical sq. in./mil)	26,100
Clarity and sparkle	Excellent
Shelf life	Unlimited
Dimensional stability	Outstanding
Heat-sealing range (1 mil)	250° to 300°F
Adhesive bonding	Fast sealing

CHEMICAL AND THERMAL		
WVTR — .001"		4.4
Gas permeability 0_2		213-300
Resistance to	weak acids, alkalies	Excellent
	strong acids, alkalies	Good
	organic solvents	Good to poor
	alcohols	Good
	oils and greases	Good to excellent
Min. use temperature		Excellent—sub-zero
Min. use temperature	Brief exposure	Up to 200°F
	Continuous exposure	175°F

**Unpigmented polystyrene — FDA approved October 15, 1956. Quarterly Bulletin of Association of Food and Drug Officials, Dr. A. J. Lehman*

PLAX CORPORATION, HARTFORD 1, CONNECTICUT

PLAX

For full information, call or write the Plax offices listed below:

NEW YORK—500 Fifth Ave.; **CHICAGO**—911 Busse Highway, Park Ridge, Illinois; **CINCINNATI**—1720 Section Road; **PHILADELPHIA**—7 East Wynnewood Road, Wynnewood, Pa.; **TORONTO**—500 St. Clair Ave. West

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Manufactured in all formulations in pellets or colorant blend.

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In every melt index and all densities.

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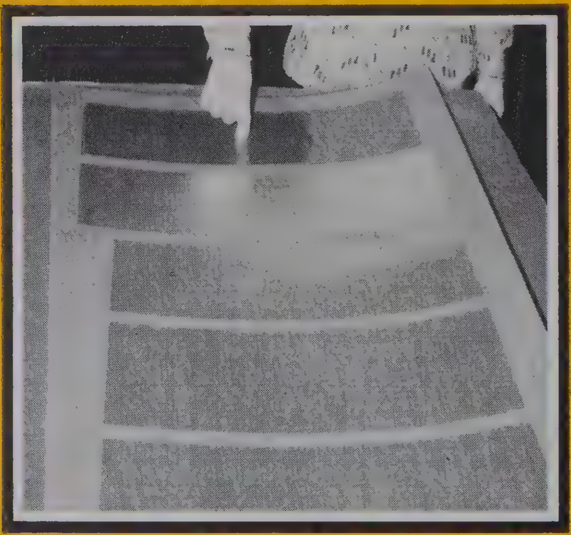
TEL: PLAZA 1-4280 CABLE ADDRESS: INPLAKO

Look at these uses for

Electronic Components. Epon resins are preferred for potting, sealing, encapsulating, and laminating because they possess outstanding electrical and physical properties. They form strong bonds to metal and glass, and assure air-tight enclosure for delicate components and vacuum tubes. They also retain excellent dimensional stability and can withstand solder bath temperatures. Photo courtesy Freed Transformer Company, Brooklyn, New York.

Tooling Applications. The unusual physical properties of Epon resins make possible the preparation of lower cost stretch dies, forming tools, drop hammer dies, jigs, duplicate master die molds, checking and assembly fixtures. Tools of outstanding strength and high quality can be fabricated to close tolerances and require little finishing. Photo courtesy of International Harvester's Milwaukee Works and Kish Industries, Inc., Lansing, Michigan.



Adhesives. Epon adhesives are used in the aircraft industry to manufacture honeycomb panels, structural joints, radar antenna, jet fuel tanks. Solvent-free Epon adhesives permit instant assembly . . . often eliminate the need for welding and riveting. Special formulations maintain a high degree of strength at temperatures up to 500° F. Photo courtesy of Convair Division, General Dynamics Corporation, Fort Worth, Texas.

Coatings. Paint users are rapidly becoming aware of the many important advantages offered by Epon resin-based formulations . . . excellent adhesion, outstanding resistance to abrasion and impact, ability to withstand extremes of heat, humidity, and the attack of corrosive chemicals. Photo courtesy of Trubeck Laboratories, Inc., East Rutherford, New Jersey, and Protex-a-Cote, Inc., Newark, New Jersey.

EPON® Resins*

a complete line of epoxy polymers

From SHELL...

SALES SPECIFICATIONS

Epon resin type	812	815	820	828	834	836	1001	1002	1004	1007	1009
Melting point, °C[1]	liq.	liq.	liq.	liq.	liq.	40-45	65-75	75-85	95-105	125-135	145-155
Color (Gardner), max.[2]	3	5	8	5	5	5	4	4	4	5	5
Viscosity[2], 25°C Gardner-Holdt Poises	— 0.9-1.5	— 5-9	— 40-100	— 100-160	O-V 4.1-9.7	A_1-B 0.30-0.7	D-G 1.0-1.7	G-K 1.7-3.0	Q-U 4.6-6.6	Y-Z_1 18-28	Z_2-Z_5 38-100
Epoxide equivalent[3]	140-160	175-195	180-195	180-195	230-280	280-350	425-550	550-700	875-1025	2000-2500	2500-4000

TYPICAL PROPERTIES

Epon resin type	812	815	820	828	834	836	1001	1002	1004	1007	1009
Weight/gal., lb.	10.2	9.5	9.7	9.7	9.7	9.9	9.9	9.6	9.6	9.6	9.9
Esterification value[4]	65	85	85	85	105	115	145	155	175	200	220

1. Durrans' Mercury Method
2. Epon 812, 815, 820 and 828 on undiluted resin; Epon 834 as a 70% solution in butyl Carbitol, all other types as 40% solutions in butyl Carbitol.
3. Grams of resin containing one gram-equivalent of epoxide.
4. Grams of resin required for complete reaction with one gram-mole of a monobasic organic acid, e.g., 60 g. of acetic acid.

When you make Shell your source for epoxy resins, you can be sure that the products you receive will meet the highest standards set by industry. Prompt delivery . . . in quantities from drums to 30,000-pound batches . . . is assured from conveniently located storage facilities.

Epon Resin Solutions—Epon 834, 836, 1001 and 1007 are also available in solution form. Additional details are available upon request.

Shell's technically trained personnel are prepared to assist you in making your products better and less costly . . . with Epon resins. Write for full information today.

Epon puts the power in paint and plastics

(*Epon resins are the epoxy polymers made exclusively by Shell Chemical Corporation)

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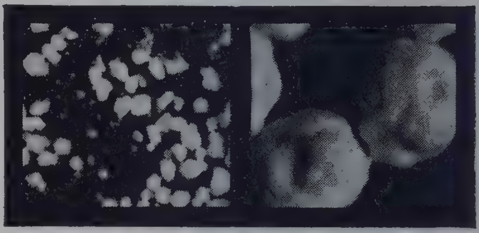
ESCAMBIA PVC RESINS

your profit can be increased with Escambia's Complete Line of PVC resins

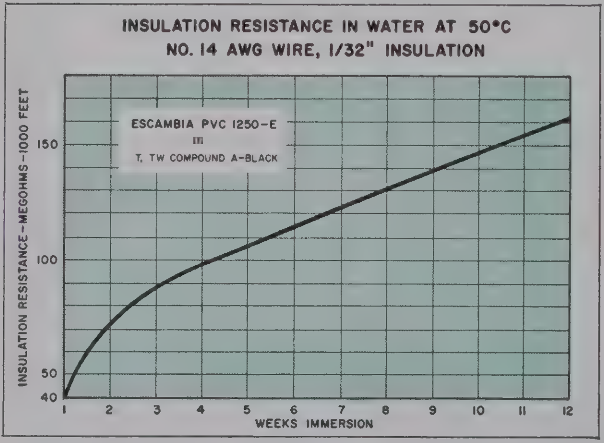
ESCAMBIA PVC PEARLS

You get the advantages of superior products from Escambia Chemical Corporation's PEARLS. Large, uniform particle size and complete *freedom from fines* characterize this series of resins and give them unusual processing advantages for special applications.

Available in a wide choice of molecular weights including the new very low molecular weights—of special importance to flooring and calendering operations. These low molecular weight resins offer processing advantages formerly obtainable only in co-polymer resins—yet they give superior product qualities not possible with co-polymer materials.



Conventional PVC *Escambia PVC Pearls*
(Each magnified 20 times)



ESCAMBIA ELECTRICAL GRADE PVC RESINS

FOUR electrical grade PVC resins in this series give you a full range of molecular weights from ONE manufacturer—enable you to:

- Meet your most difficult specifications
- Operate at your most efficient speeds and temperatures
- Produce outstanding electrical products

You are now able to choose the molecular weight best suited to your own operating conditions. These resins give you free-flowing dry blends, extremely low gel count, freedom from fines, uniform particle size, excellent color and clarity and outstanding insulation resistance.

ESCAMBIA GENERAL PURPOSE PVC RESINS

These general purpose PVC resins deliver money saving benefits to your plant.

- Free-flowing dry blends
- Extremely low gel count
- Excellent color and clarity
- Uniform particle size
- Freedom from fines
- Outstanding heat stability

Available in a wide range of molecular weights, including the new very low molecular weight resins with superior plastic flow characteristics.

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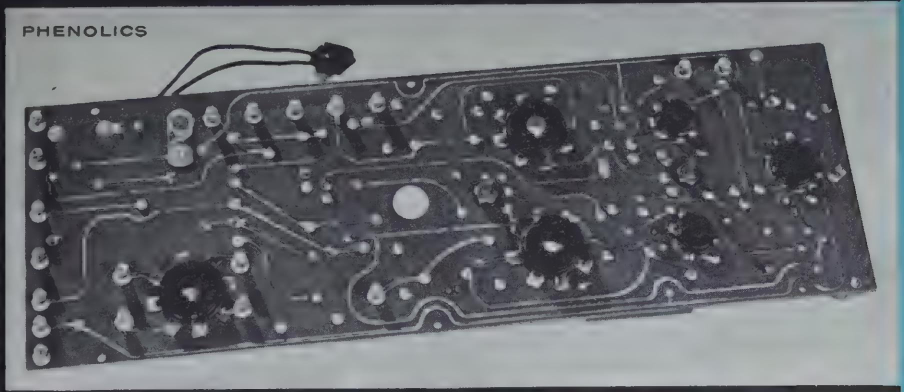
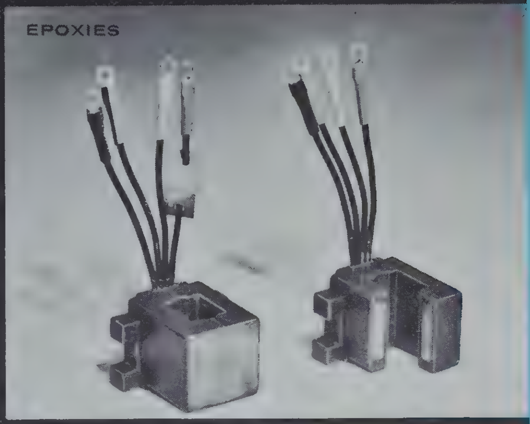


POLYETHYLENES

EPOXIES



POLYSTYRENES

VINYLS

UNION CARBIDE PLASTICS COMPANY

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FEATURING ***PLASTIC MATERIALS***
THAT ARE VERSATILE,
ADAPTABLE, AND
EASILY FABRICATED.

UNION CARBIDE

THERMOPLASTIC

POLYETHYLENE

	LOW DENSITY	MED. DENSITY	HIGH DENSITY
MECHANICAL PROPERTIES			
a. Modulus of elasticity, 10^3 psi	14-38	35-90	85-160
b. Tensile strength, psi	1500-2400	1600-2500	2500-5000
c. Ultimate elongation, %	400-700	200-500	10-300
d. Yield Stress, psi	1100-1700	1500-2600	2500-5000
e. Yield Strain, %	20-40	10-20	5-10
f. Rockwell hardness			R30-R50
g. Notched Izod impact strength, ft. lb./in.			1-10
h. Specific Gravity	0.912-0.925	0.926-0.941	0.942-0.965
MISCELLANEOUS PROPERTIES			
a. Clarity	Translucent	Translucent	Translucent
b. Color	Colorless	Colorless	Colorless
c. Refractive Index	1.50-1.54	1.50-1.54	1.50-1.54
ELECTRICAL PROPERTIES			
a. D.C. Resistivity, ohm-cm	$>10^{15}$	$>10^{15}$	$>10^{15}$
b. Dielectric Constant 60 cps	2.3	2.3	2.3
c. Dielectric Constant 10^6 cps	2.3	2.3	2.3
d. Dissipation Factor 60 cps	<0.0005	<0.0005	<0.0005
e. Dissipation Factor 10^6 cps	<0.0005	<0.0005	<0.0005
THERMAL PROPERTIES			
a. Burning Rate	Medium	Medium	Medium
b. Heat Distortion 264 psi, deg. C			
c. Specific Heat cal/gm	0.55	0.55	0.55
d. Thermal Coefficient of Expansion, linear 10^{-5} deg. C	15-30	15-30	15-30
e. Maximum Continuous Service Temperature, deg. F	60-77	71-93	93-200
CHEMICAL RESISTANCE*			
a. Mineral acids, weak	Excellent	Excellent	Excellent
b. Mineral acids, strong	Excellent	Excellent	Excellent
c. Oxidizing acids, concentrated	Good to Slight	Good to Slight	Good to Slight
d. Alkalies, weak	Excellent	Excellent	Excellent
e. Alkalies, strong	Excellent	Excellent	Excellent
f. Alcohols	———	Varies widely from Exc. to Slight	———
g. Ketones	———	Varies widely from Exc. to Slight	———
h. Esters	———	Varies widely from Exc. to Slight	———
i. Hydrocarbons, aliphatic	Fair	Fair	Fair
j. Hydrocarbons, aromatic	Fair	Fair	Fair
k. Oils, vegetable, animal, mineral	Good	Good	Good

*Remember, polyethylene can easily be combined with films, foils and papers to provide "tailor-made" resistances.

BAKELITE

BRAND

POLYETHYLENE

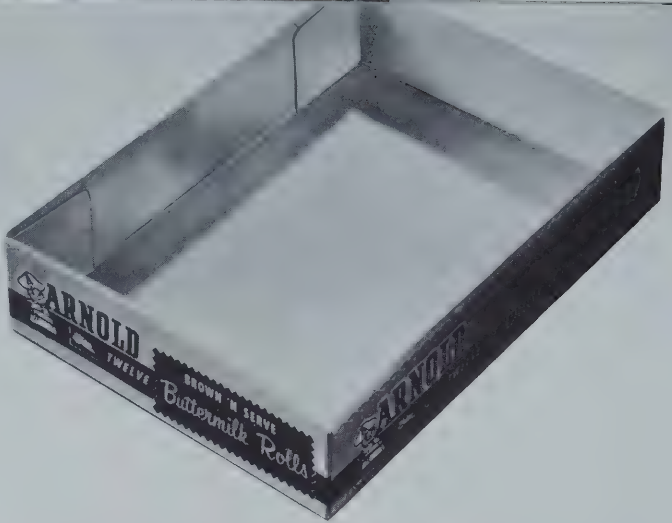
A PLASTIC WITH EVER-WIDENING FIELDS OF APPLICATION

Born of wartime need for wartime uses, polyethylene now serves many industries in many ways. One of the pioneers in the commercial development of polyethylene, Union Carbide Plastics Company markets polyethylene resins and compounds for *molding, extrusion, calendering* and *extrusion coating*.

Polyethylene is available in grades ranging from high-density (sp. gr. .965), fairly rigid compounds, to low-density (sp. gr. .912), flexible materials.

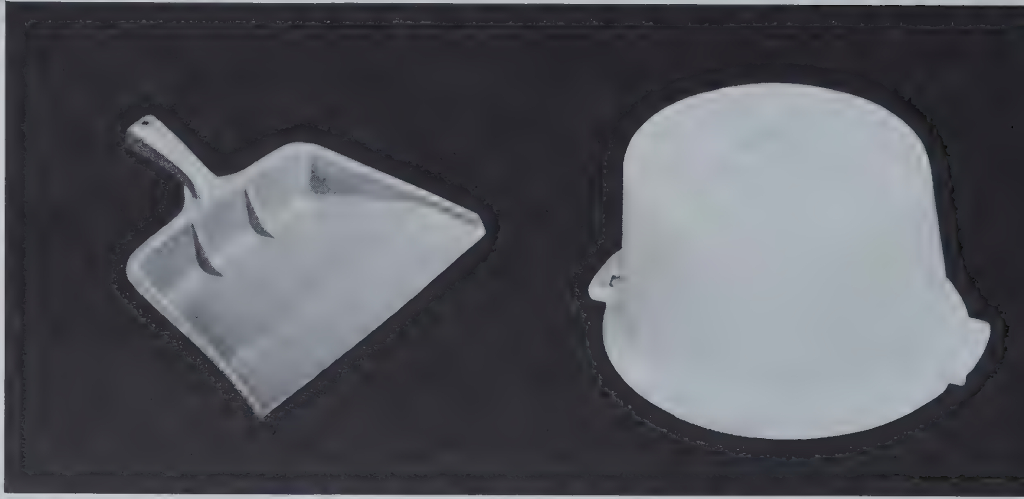
A big step in packaging with polyethylene film is the automatic overwrapping of bread. Techniques developed by film and machinery suppliers now allow the baker to benefit from the improved transparency and low cost of polyethylene film.

Large sections of pipe can easily be handled without power equipment when they are extruded from polyethylene resins. The chemical resistance of polyethylene provides long life in the ground—the pipe cannot contaminate the water with rust or scale.



Coatings of polyethylene, extruded onto cardboard stock, increase the moisture resistance and reduce sticking. The product is thus doubly protected from drying out and from crumbling during removal.

Strawberries are successfully mulched with agricultural grade polyethylene film. The growers report greater yield per acre and marked reduction of weeding and cultivating. The film is laid over the strawberry rows and then slit over each plant. As the plant grows, moisture is retained under the film and weed growth is choked off. Black film is also widely used.



Housewares of injection molded polyethylene bring color and ease of cleaning into the home. The unbreakable, undentable, lightweight polyethylene provides safety and long life.

THERMOPLASTIC VINYL RESINS

RIGID	NON-RIGID (PLASTICIZED)
200-600	
5000-9000	2000-3000
	200-400
1-5	
R110-R120	
0.4-1.0	
1.36-1.41	1.15-1.65
Transparent	Trans-opaque
Colorless to Amber	Colorless to Amber
1.54	1.50-1.55
10^{12}-10^{16}	10^{11}-10^{14}
3-4	3-11
3-4	3-4
0.01-0.02	0.03-0.13
0.01-0.02	0.06-0.10
Self Extinguishing	Slow to Self Extinguishing
60-80	
0.20-0.28	0.36
5-6	
70-74	80-105
Excellent	Good to Fair
Exc. to Good	Good to Fair
Good to Fair	Fair to Slight
Excellent	Good to Fair
Good	Good to Fair
Excellent	Fair
Slight	Slight
Slight	Slight
Excellent	Slight
Slight	Slight
Excellent	Slight

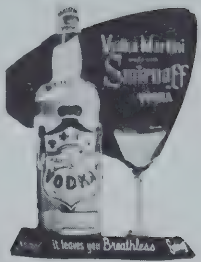
BAKELITE
BRAND
VINYL

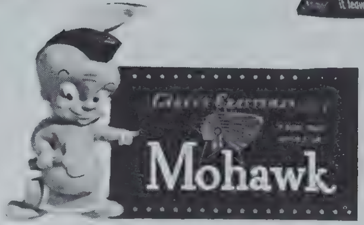
THE LARGEST VARIETY FOR THE WIDEST RANGE OF APPLICATIONS

Vinyl plastic compounds and resins are used in so many ways for such diverse end uses that they have been called the "kingpins" of the plastics industry. The development of plastisols and rigidsols allows vinyl resins to be fabricated into colorful end products without a large initial investment. The excellent aging and coloring properties, flexibility, dielectric strength and high power factor of the extruded and molded materials have increased their use in the electrical insulation field. The excellent abrasion, weather and chemical resistance of these materials promise to increase the already numerous uses for vinyls.

Colored and natural vinyl compounds and resins for *coating, casting, foaming, molding, calendering, bonding* and *extruding*, as well as *calendered and cast, rigid and flexible, film and sheeting* are all manufactured by Union Carbide Plastics Company.

Soaring luminous ceilings of rigid vinyl sheeting provide glare-free light for showrooms, banks and other public institutions. Rigid vinyl sheeting will soften and fall away from the ceiling when subjected to high heats. The sprinkler systems are then free to operate at peak efficiency. The sheeting will also hide piping and ductwork but not obstruct their maintenance. ▲





Vinyl sheets, vacuum formed into brilliant displays for point-of-purchase advertising, are an example of the versatility of vinyl materials. The signs are lightweight and fade resistant.

Coatings based on vinyl resins provide weather protection on ship or shore. Easily applied to concrete, metal, wood, paper, or plaster, they drastically reduce maintenance expenses by providing quick drying time and long service life.

The sparkling clarity of KRENE cast vinyl film is evident in skin packages and wrapping film. The vinyl provides flexibility and toughness that are extremely desirable in many applications. Colored film is also used widely for inflatable toys, weather covers, vinyl silos and swimming pool liners.

Non-rigid vinyl compounds make parts that are tough and long-lasting. They are easily molded into non-marring vacuum cleaner parts, kick panels, rub rails and novelty items requiring elastomeric properties.

VINYLfoam can be fully core- and contour-molded to make mattresses and T cushions as shown. Easily bonded to vinyl film, metal, fabric or wood, colorful vinylfoam is finding successful applications in many fields.

GENERAL PURPOSE THERMOSETTING
PHENOLICS
FOR MOLDING*

800-1200
6500-8500
0.6-1.0

M110-M120
0.24-0.34
1.32-1.55

Opaque

10^{11}-10^{13}
5-9
4-7
0.04-0.3
0.03-0.07

Self Extinguishing
143-171
0.35-0.40
3.0-4.5
149-177

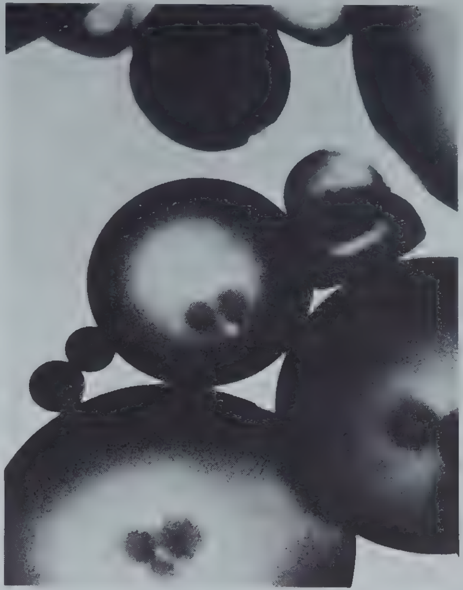
Varies
Slight
Slight
Varies
Slight
Exc. to Good
Fair
Good to Fair
Excellent
Excellent
Excellent

*Specialized data on phenolic compounds for bonding, laminating, impregnating and coating can be obtained from the Bakelite Company Technical Representatives who are located in Sales Offices from coast to coast.

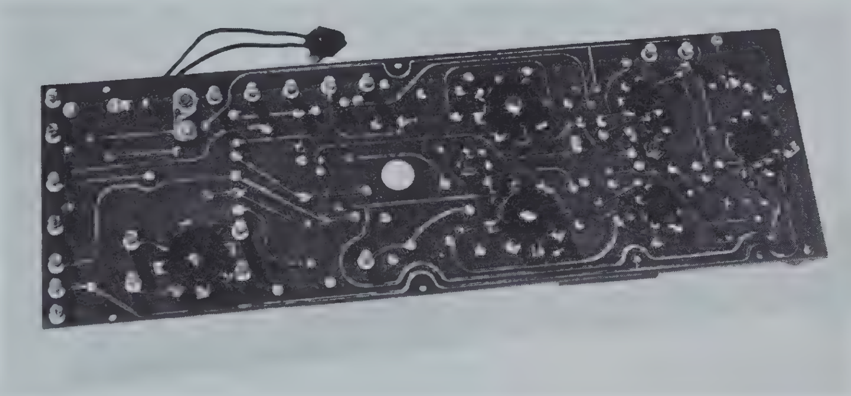
BAKELITE
BRAND
PHENOLICS
FOR DEPENDABILITY AND VERSATILITY

Created at the turn of the century, phenolic plastics are now marketed by Union Carbide Plastics Company for *molding, coating, bonding, laminating* and *foaming*. The molding compounds are combined with various fillers such as cellulose, minerals or wood flour to provide a wide range of heat, shock and electrical resistance. Also, phenolic resins are cooked with various oils to give a wide variety of coating compounds.

The many-year protection given to this bridge by phenolic coatings has reduced maintenance and improved appearance. Resisting extreme weathering and salt air corrosion, phenolic coatings have served on the bridge for seventeen years.

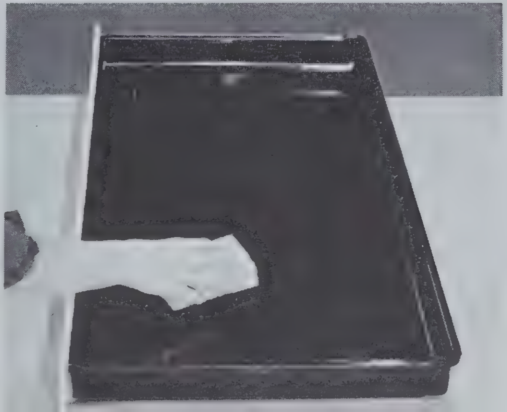


Microscopic, hollow, phenolic spheres, when mixed with a bonding resin, provide a strong, lightweight, syntactic foam for molding boat hulls. Used alone, they form a floating blanket in crude oil tanks to cut evaporation losses. Thus, two widely separated applications are served by a common material—phenolic.



The printed circuits needed for advanced electronic machines get a big performance boost from the excellent electrical properties provided by phenolic laminating resins. Strength and high temperature resistance are also important.

Phenolic bonding resins save time and money in pouring green sand molds. The added strength imparted to the sand by the resins increases service life and quality of the molded item.



Compression molded phenolic drawers eliminate sticking and splintering. Rounded corners and glossy surface ease the cleaning chore. Colored epoxy coatings or wood laminate fronts allow the drawers to harmonize in any setting, rustic or modern.

THERMOPLASTIC

POLYSTYRENE

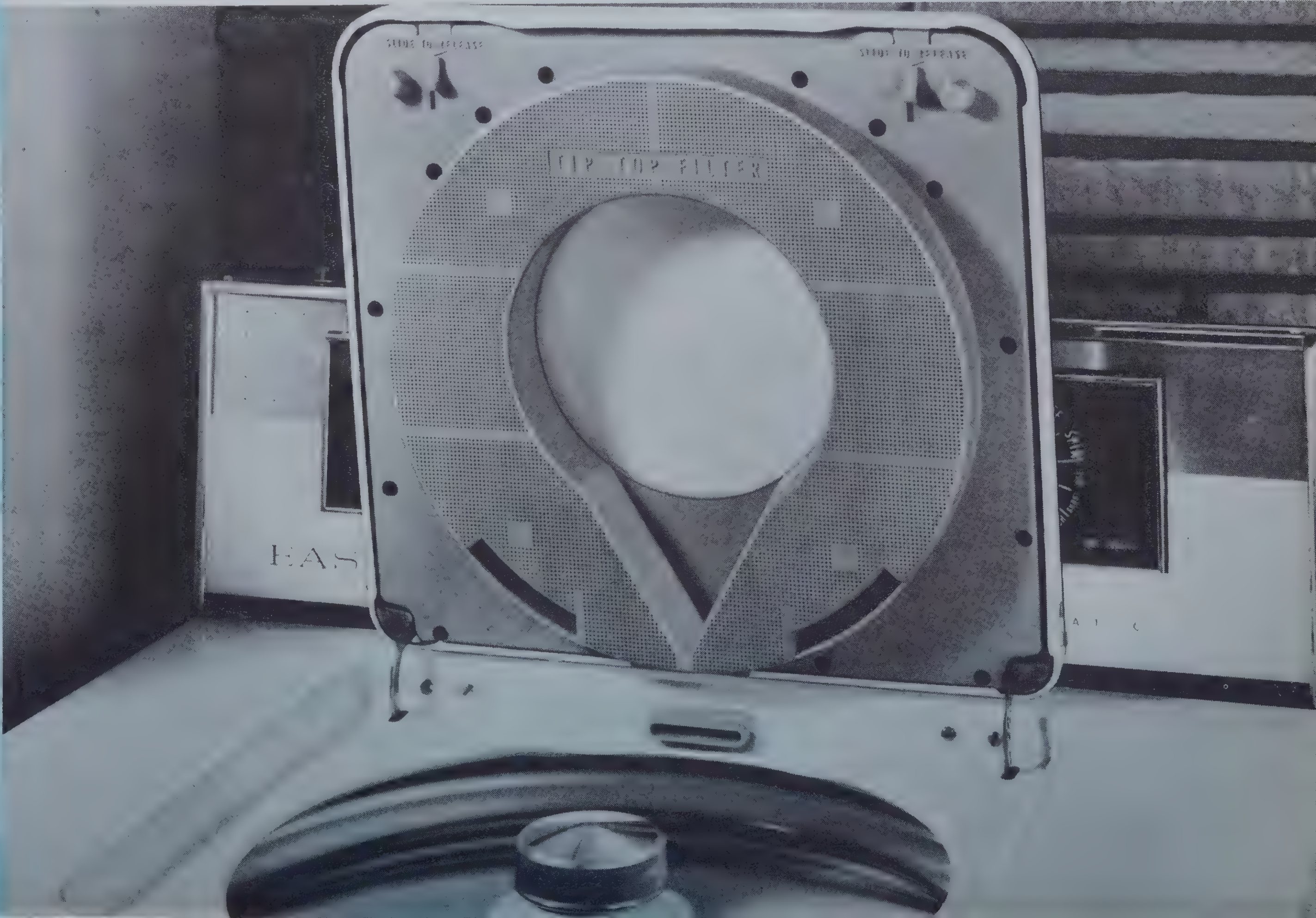
UNMODIFIED	STYRENE ACRYLONITRILE
400-600	400-600
5500-9500	6000-12000
1.0-2.5	1.0-3.5
M70-M85	M75-M90
0.25-0.60	0.3-0.6
1.05-1.08	1.05-1.10
Transparent	Transparent
Colorless	Colorless to Si. Amber
1.585-1.600	1.57-1.60
10^{17}-10^{21}	10^{13}-10^{17}
2.50-2.65	2.6-3.4
2.50-2.65	2.5-3.1
<0.0005	0.0005-0.001
<0.0005	0.0005-0.001
Medium	Medium
30-99	91-104
0.32-0.35	0.32-0.35
6-8	6.0-8.0
66-82	77-88
Excellent	Excellent
Excellent	Exc. to Good
Exc. to Slight	Fair to Slight
Excellent	Excellent
Excellent	Exc. to Good
Excellent	Exc. to Good
Dissolves	Dissolves
Slight	Fair to Slight
Slight	Exc. to Good
Dissolves	Good to Fair
Fair to Slight	Exc. to Good

BAKELITE
BRAND

POLYSTYRENE

A PLASTIC THAT TOUCHES ALL INDUSTRIES

A quarter of a century has seen polystyrenes used in an almost infinite number of ways. Rubber modification and styrene copolymerization have added new properties and uses to the basic styrene materials. Union Carbide Plastics Company supplies polystyrene compounds for *extrusion* and *molding*.



water, heat and constant use. Impact polystyrene meets the challenge and adds one more important property—the ability to be molded into intricate, thin sections. The colorful, lightweight polystyrene brings praise from both housewife and appliance manufacturer.

a Extruded styrene sheet can be easily vacuum formed into any number of items. The toy typewriter illustrates the detail that can be expected from a quality vacuum-forming operation. The low cost of the sheet and the low initial investment of the forming equipment make the process particularly attractive to manufacturers with high volume products.

b A brush made with styrene monofilament bristles is perfectly adapted for cleaning snow off walks. The brightly colored filaments are easily cleaned, resist hard usage and are not affected by moisture and cold.

c BAKELITE C-11 styrene-acrylonitrile copolymer is ideally suited for molding airline serving trays. The unique properties of C-11 result in reduced breakage and the elimination of serving utensils that are excessively hot. C-11 possesses exceptional chemical and impact resistance and can be molded in a wide range of colors.

a

b

c

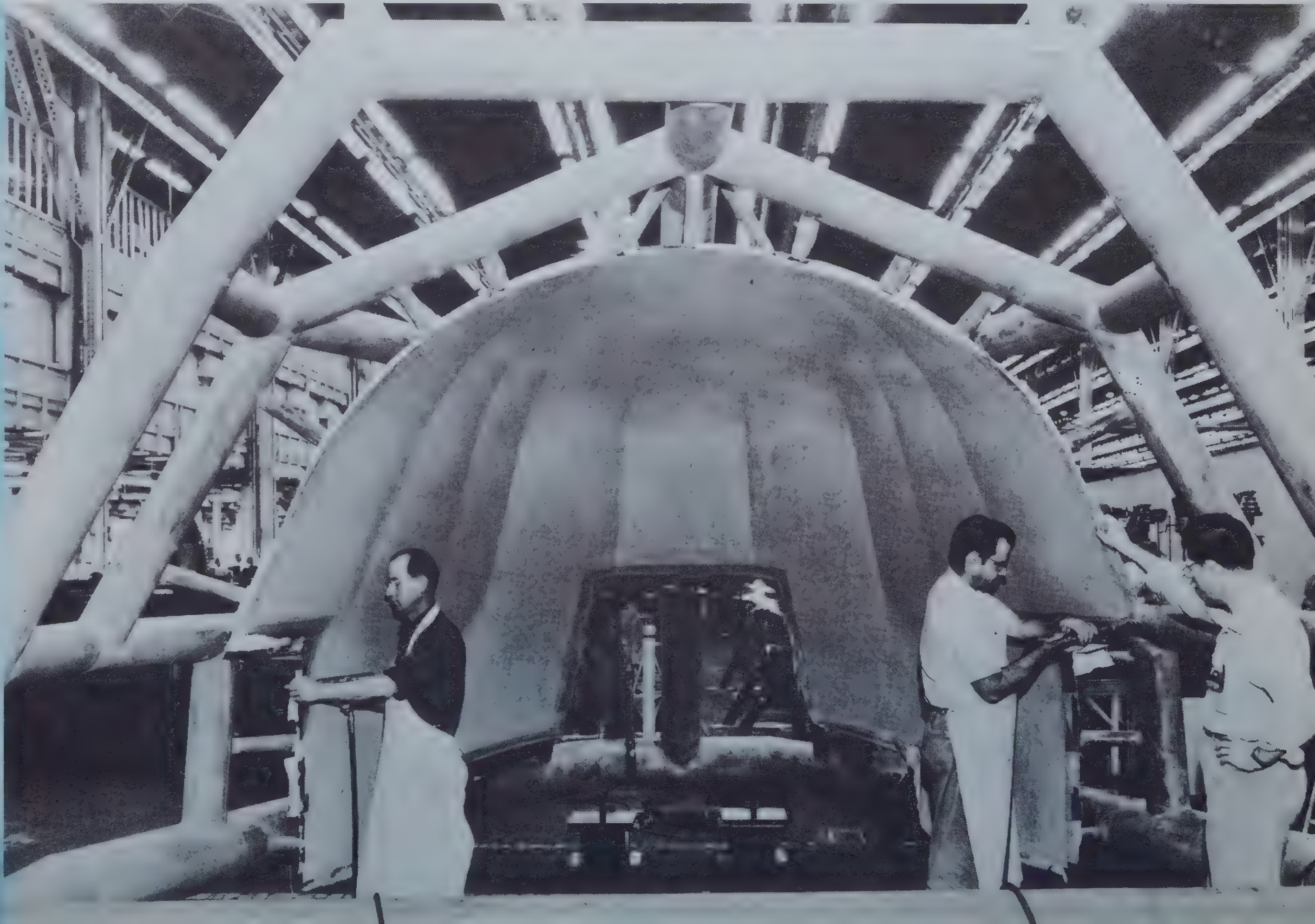
Glittering metallic colors for injection molded toys have proved popular with children and molders alike. High-impact strength is manufactured-in for breakage resistance and structural rigidity.

THERMOSETTING **EPOXY** UNMODIFIED
>300
>2000
2-6
M75-M110
0.16-0.7
1.115
Transparent
Almost colorless
1.58
10^{12}-10^{14}
3.5-5.0
3.4-4.4
0.001-0.015
0.015-0.035
Slow
Up to 120
0.25-0.4
3-9
80
Excellent
Good to Fair
Slight
Excellent
Excellent
Excellent
Slight
Excellent
Excellent
Excellent

BAKELITE
BRAND
EPOXY

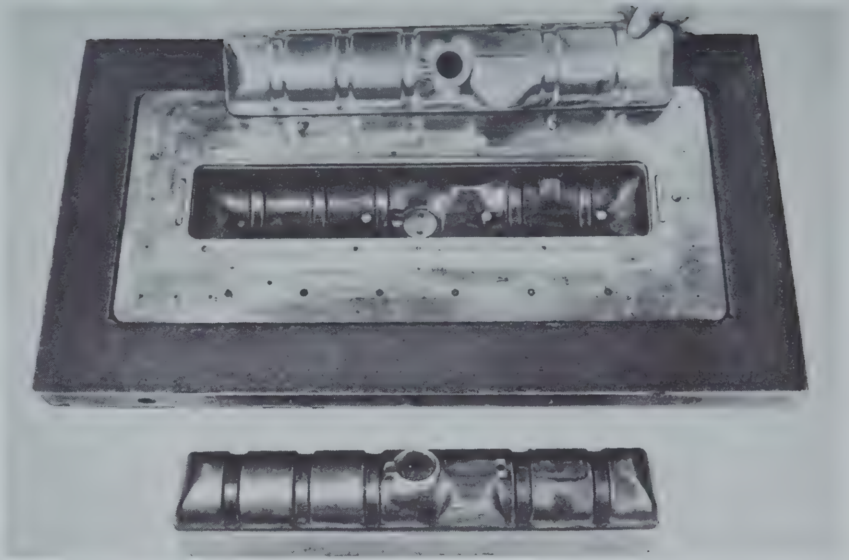
IMPRESSIVE IN GROWTH AND OUTSTANDING IN PROPERTIES

Quick acceptance of epoxy resins can be attributed to their adhesive qualities, colorability and chemical, moisture and fungus resistance. Union Carbide Plastics offers epoxy resins for *coating, laminating, adhesives, tool making, bonding* and *alloying with metal and cloth fibers.*

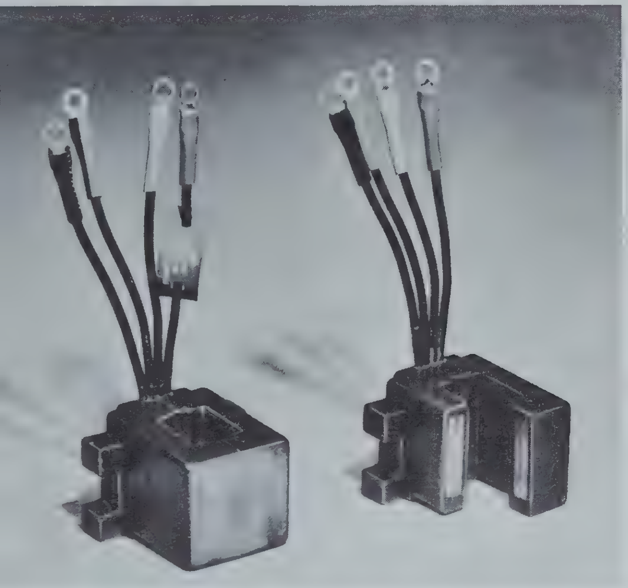


laminating resins save time and money. The aircraft industries were among the first to recognize the weight/dollar savings available from this "young" plastic. This aircraft positioning jig was assembled in a fraction of the time normally consumed, and at a fraction of the cost.

Epoxy-based coatings for appliances like this television set can reduce the cost to well below that of an electro-plating finish. The coating is a mixture of bronze powder and epoxy resin, finished with clear epoxy. Thus, the appliance is given a corrosion, chemical and impact resistant surface that can be wiped clean and is permanently colored.



The addition of metal fibers to epoxy compounds increases the impact strength and abrasion resistance. These Epoxy-Alloys are used for medium run stamping dies with great success. This Epoxy-Alloy punch and die for brass radiator tank tops completed 130,000 cycles with no appreciable wear.



The encapsulating of electrical compounds must be done with great care and with a material that provides excellent electrical insulation. Epoxy compounds are widely used because they can provide this insulation and have an almost negligible shrinkage during cure. The low viscosity of the uncured resins allows for complete penetration into the tiniest cracks and crevices.

The adhesive properties of epoxy resins make them ideal for industrial and home repairs. Successfully used to bond such materials as glass, china, wood, metal and plastics, they are finding great success in making "impossible" repairs.

NOTED FOR YOUR CONVENIENCE

Union Carbide Plastics Company's Technical Representatives, located in Sales Offices throughout the country, are in a position to answer particular questions and to supply precise technical information concerning plastic raw materials marketed by the Company. Their training enables them to evaluate the properties of a particular plastic and also to suggest methods of fabrication.

The data contained herein is of general nature and relates to the five major plastic raw materials currently being marketed by Union Carbide Plastics Company. There are many compounds in each class to fill particular needs. Information on specific requirements or end uses can be obtained at Union Carbide Plastics Company Sales Offices.

UNION CARBIDE PLASTICS COMPANY

DIVISION OF UNION CARBIDE CORPORATION

The terms BAKELITE, KRENE, and UNION CARBIDE

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CLEVELAND 14, O., 1300 Lakeside Avenue, N. E.
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DETROIT 21, MICH., 10421 W. 7 Mile Road
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UNION CARBIDE INTERNATIONAL COMPANY
Division of Union Carbide Corporation
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Cable Address: UNICARBIDE, New York

G.Q.*

/m.s.!

*GERING QUALITY MEANS SAVINGS

in all thermoplastic injection molding and extrusion compounds

• Polyethylene • Vinyl • Styrene • Impact Styrene
• Acetate • Nylon • Acrylic • Styrene Copolymer • Butyrate

G.Q./M.S.–it's the shortcut way to top quality, uniformly blended molding compounds — made under exacting quality controls! Result: you cut costs without sacrificing quality!

GERING
Molding Compounds

Cable Address: GERING • TWX Cranford, N. J. 137

GERING PLASTICS division of STUDEBAKER-PACKARD CORP. **Kenilworth, N. J.**

Sales Offices: 5143 Diversey Ave., Chicago 39, Ill. • 1115 Larchwood Rd., Mansfield, Ohio • 216 Wild Ave., Cuyahoga Falls, Ohio • 103 Holden St., Holden, Mass.

TENITE
BUTYRATE

PROPERTIES: Extremely tough, excellent impact strength, resilient, lightweight, lustrous, weather resistant, dimensionally stable. Available in a wide variety of formulations and an almost unlimited range of transparent, translucent, opaque, metallic and variegated colors plus a crystal-like clear.

Adapted to fast injection molding or continuous extrusion.

TYPICAL USES: Steering wheels, telephone housings, business machine keys, optical frames, tool handles, football helmets, industrial pipe, skin and blister packaging, outdoor signs.

TENITE
PROPIONATE

PROPERTIES: A cellulosic with physical properties that, in general, range between those of Acetate and Butyrate. Available in a variety of formulations and a wide range of clear and opaque colors.

Adapted to fast injection molding or continuous extrusion.

TYPICAL USES: Telephone housings, handles, packaging sleeves, cosmetic cases, pen and pencil barrels, jewelry cases.

TENITE
ACETATE

PROPERTIES: The original Tenite plastic, offering a wide range of desirable properties including toughness, light weight, impact strength, enduring luster and low heat conductivity. Available in a variety of formulations and almost unlimited colors.

Adapted to fast injection molding or continuous extrusion.

TYPICAL USES: Shoe heels, small appliance housings and parts, toothbrush and other tubular containers, toys, novelties, lamp shades, vacuum cleaner parts.

TENITE

POLYETHYLENE

VERSATILE

TENITE PLASTICS

TOUGH

DURABLE

GLOSSY FINISH

INFINITE COLOR RANGE

PROPERTIES: Flexible or semi-rigid, virtually unbreakable, chemically inert, resistant to water and moisture transmission and to strong acids, excellent electric insulator. Available in natural or wide range of colors and color concentrates, with or without an antioxidant.

Adapted to rapid injection molding, blow molding, or continuous extrusion.

For a colorful thermoplastic with long service life, consider the combination of properties offered by each of the four Tenite plastics —Butyrate, Propionate, Acetate and Polyethylene. Almost 40,000 different color formulations and samples already are on file in the Tenite Color Laboratory. Whether your plastic application is for indoor or outdoor use, there's a Tenite formulation to meet your design needs...to satisfy your performance requirements ...to suit your manufacturing facilities.

TYPICAL USES: Housewares, toys, bottles, packaging film, pipe and tubing, electric cable wrap and wire coating, coatings for paper, film and foil.

TENITE REPRESENTATIVES are qualified plastics engineers ready to help in the design or production of plastic products. You'll find them listed under "Plastics — Tenite" in the classified telephone directories of these cities: Atlanta, Chicago, Cleveland, Dallas, Dayton, Detroit, Greensboro (N. C.), Kansas City, Leominster (Mass.), Los Angeles, New York City, Portland (Ore.), Rochester (N. Y.), St. Louis, San Francisco, Seattle, Toronto.

EASTMAN CHEMICAL PRODUCTS, INC.

subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE

POLYSTYRENE IN BULK

BY TRUCK OR BY RAIL

BULK SHIPMENTS . . . Cosden's representatives are specially trained and experienced to help you initiate a money saving program for handling bulk shipments of Polystyrene. Pneumatically equipped rail and truck facilities insure fast, efficient handling and product purity.

REALISTIC SAVINGS are assured by eliminating multiple handlings, packaging, warehousing, contamination, and nonproductive operations. Further savings are possible through Cosden's quantity purchase plan.

COMPARE QUALITY — SAVINGS — CONVENIENCE . . . Cosden produces polystyrene from natural resource to finished product in the only completely integrated plant in the industry. Compare the controlled quality of Cosden's "Jewelsheen" polystyrene, available in general purpose and high impact grades. Compare the sizable savings afforded both in product and handling costs. Compare the convenience and efficiency of bulk handling.

Many molders have already made the switch to bulk. Why don't you investigate soon?

One of our experienced representatives would like to discuss with you our product and the advantages of bulk shipments. Write or call — Box 1311, telephone AMHERST 4-4661.

COSDEN

COSDEN PETROLEUM CORPORATION · BIG SPRING, TEXAS

SPARKS
NEW
PRODUCT
IDEA

CUTS
MANUFACTURING
COSTS

Grace presents the High Density Polyethylene Profit Parade

CREATES
EXCLUSIVE
SELLING
ADVANTAGE

ANSWERS
TOUGH
PACKAGING
PROBLEM

Profit Parade Products Demonstrate

A new product idea combining the toughness of high density polyethylene with the appeal of fantastic animals is winning new sales. These zoo inhabitants are sold as individual "out-of-the-world" creatures in kits of interchangeable parts—rigid, to snap together, pull apart in millions of ways—with strength to withstand the roughest juvenile or adult treatment. This play-proof Grace plastic provides a profitable product that will not break, chip or crack—is molded in permanent high-style, soft pastel colors—takes scrubbing or sterilizing without harmful effect—is colorfast and nontoxic.

Exclusive selling advantages are built into this "Lifetime Tub" by Baby Bathinette Corporation. The manufacturer selected Grex high density polyethylene from Grace to give the tub features that really make sense to mothers. Made to far outlast competitive models, the tub has a soft, pleasant texture, is easy to carry and keep clean, is rigid, strong and virtually indestructible. The "Lifetime Tub" even has a useful life after baby outgrows it. Most important from a manufacturing standpoint, a product of such large size (30½" x 6½" x 19") still offers the economy of injection molding.

GRACE

High Density Polyethylene

The Only Plastic to Offer
These Profit-Building Properties

- Rigid, strong, tough
- Can be boiled or autoclaved
- Retains its strength at freezing and below
- Resists attack of most chemicals
- Has excellent electrical properties
- Outstanding moisture and gas barrier
- Can be molded in any color and decorated
- Available in flame retardant compounds

Major Benefits of New Grace Plastic

Reduction in manufacturing costs is often accomplished by specifying parts made of Grex high density polyethylene. An excellent example is this TV tube socket now being used in sets of leading manufacturers. The part is injection molded of high density polyethylene at a cost significantly lower than that of competing sockets which are compression molded of thermosetting resins. Without sacrificing performance for cost, the socket has good electrical insulating properties, resistance to heat (up to 250°F.), will not warp or break in installation, and meets UL standards by being molded in a flame retardant compound produced by Grace.

Solution to a tough packaging problem has enabled Columbia Ice and Ice Cream Company to introduce a new type of light frozen cheese cake which offers a strong consumer appeal by retaining its original moisture and mouthwatering flavor. Heat sealed bags of high density polyethylene film were chosen for the packaging job since this plastic offers better moisture barrier properties than any other film of comparable cost. Tests show that the 2-mil film bag retains moisture at least three times more effectively than film of conventional polyethylene. It is crisp and rip-resistant for easier loading—colorfully printed for impact at point of sale.

9 Grex Resins Meet Every Fabricating Need

Product Designation	Injection Molding	General Extrusion	Film	Mono-filament	Pipe & Wire Covering	Paper Coating	Blow Molding	Sheet	Vacuum Forming
50-004C		X		X	X		X	X	
50-020C*	X								
50-050C*	X		X			X			
50-090C	X		X			X			
60-002E		X		X			X	X	X
60-007E*	X	X	X	X			X	X	
60-020E	X								
60-035E	X								
60-050E*	X		X						

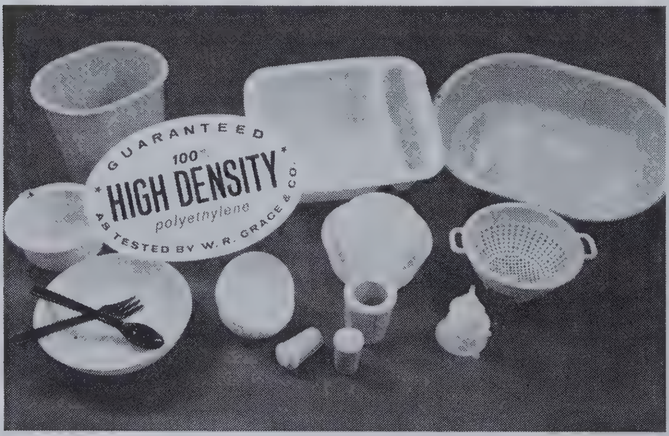
**Available in flame retardant compounds that render the resin self extinguishing.*

Grace Service Puts Your Product in the High Density Polyethylene Profit Parade

High density polyethylene is geared to help you meet today's manufacturing and marketing problems. If you want to cash in on the promise of this new plastic by improving an existing product, cutting costs or developing something entirely new—it pays to call in the *specialists* on high density polyethylene. Just look what Grace Service has to offer.

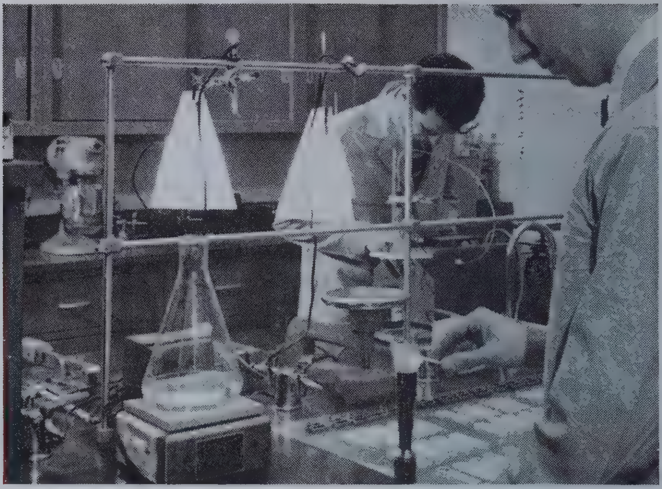
LARGE-SCALE PRODUCTION FACILITIES

The Grace Polymer plant at Baton Rouge, Louisiana is the newest and one of the largest of all W. R. Grace & Co. chemical plants. It is rated at an annual capacity of 50 million pounds of resin to assure you a uniform supply of Grex high density polyethylene in the quantities you require.



MERCHANDISING SERVICES

The Grace Merchandising Services Department is vitally interested in helping you sell your customers—works continually with manufacturers of consumer goods in areas of labelling, market development, sales, distribution, advertising, promotion and publicity.



PIONEERING POLYMER RESEARCH

From this creative research and development group—often working with the W. R. Grace & Co. Washington Research Center—have come important breakthroughs in polyethylene production and improved resins. Grace customers are always first to benefit from the results of this research program.

TECHNICAL SERVICE LABORATORIES

Here is where Grace meets and solves practical technical problems relating to fabrication, design and performance of high density polyethylene products. Production-type machines make it possible to duplicate actual plant operations, and modern laboratories are fully equipped for physical, chemical and electric testing.

YOUR GRACE TECHNICAL REPRESENTATIVE

He's a technical expert on high density polyethylene *and* a salesman. The needs, problems and ideas of his customers are foremost in his mind. He's in a position to call in production, research, technical service and merchandising teams to give you the help you need.

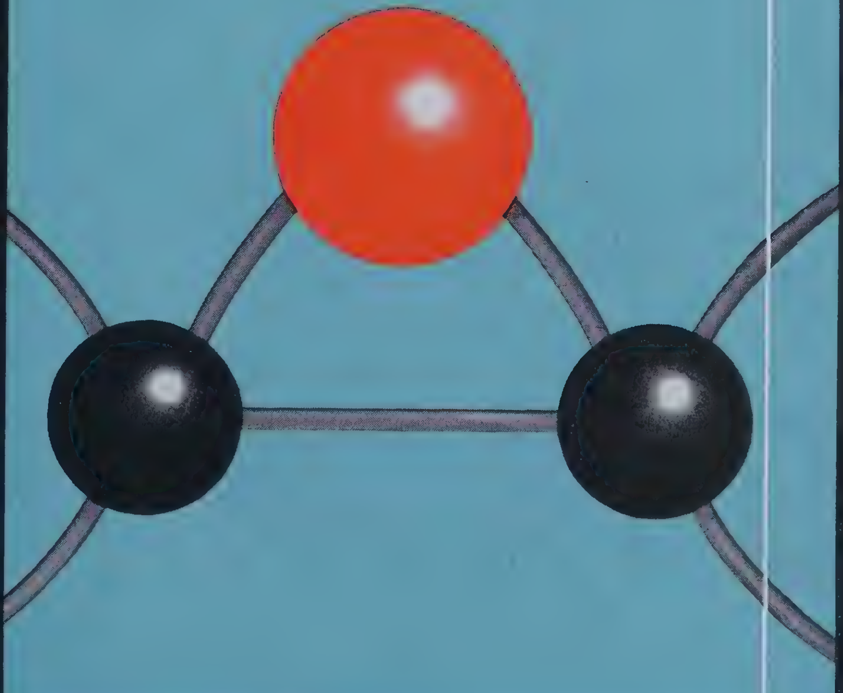
W. R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY

POLYMER GRACE CHEMICALS

CIBA

ARALDITE® EPOXY RESINS

OXIRANE RING...THE EPOXY BUILDING BLOCK



ARALDITE EPOXY RESINS PROPERTIES AND APPLICATIONS

		RESIN	RD-1	RD-2	502	506	6005	6010
PROPERTIES		epoxy content						
		1. epoxy value (equivalent/100 g resin)	0.70	0.75	0.38	0.54	0.52	0.51
		2. epoxy equivalent (gms resin/g-mol epoxide)	143	133	263	185	192	196
		esterification equivalent (grams resin esterified by g equiv. acid)	—	—	—	—	—	—
		specific gravity	0.90	1.10	1.15	1.13	1.16	1.16
		color (Gardner)	<1	5	3	2	2	2
		melting point (Durrans) °C.	(liquid)	(liquid)	(liquid)	(liquid)	(liquid)	(liquid)
		viscosity (at 25°C.) Brookfield (cps)	3	19	3,000	800	9,500	14,000
		Gardner-Holdt	—	—	—	—	Z_4	Z_5
STRUCTURAL		Adhesives		✓	✓		✓	✓
		Body "Solders"	✓	✓	✓	✓	✓	✓
		Casting	✓	✓	✓	✓	✓	✓
		Caulking and Sealants	✓	✓	✓	✓	✓	✓
		Electrical	✓	✓	✓	✓	✓	✓
		Impregnating	✓	✓	✓	✓	✓	✓
		Laminating	✓	✓	✓	✓	✓	✓
		Tooling	✓	✓	✓	✓	✓	✓
COATINGS	MAINTENANCE	Equipment Finishes						
		Marine Finishes						
		Masonry Finishes			✓			
		Structural Steel Coatings						
		Tank Coatings						
	PRODUCT FINISHING	Aircraft Finishes						
		Appliance Primers						
		Automotive Primers						
		Can & Drum Linings						
		Chemical Resistant Finishes			✓			
		Collapsible Tube Coatings						
		Furniture Finishes						
		Metal Decorating Finishes						
		Pipe & Tank Linings						
	TRADE SALES	Concrete Floor Paints						
		Gym and Floor Varnishes						
		Spar Varnishes						
OTHER USES		Decorative Flooring—Epoxy/Marble Chip			✓			
		Floor Topping—Industrial	✓	✓	✓	✓		
		Printing Inks						
		Road Toppings			✓			
		Vinyl Stabilizers				✓		

● In U.S.A. and Canada CIBA produces basic resins only, to be formulated for intermediate and end uses.

CIBA manufactures a wide range of epoxy resins, hardeners, and modifiers to suit every application requirement. The chart below summarizes typical specification data and recommended end uses.

CIBA

FIRST IN EPOXIES

6020	6030	6040*	6060	6071*	6075	6084‡	6097*	6099	7071*	7097*
0.48	0.44	0.37	0.24	0,205	0.14	0.105	0.046	0.031	0.205	0.055
208	227	270	417	485	715	950	2200	3200	485	1800
—	—	—	—	130	185	175	190	200	—	—
1.16	1.16	1.16	1.19	1.21	1.19	1.15	1.15	1.19	1.12	1.14
3	5	6	4†	4†	4†	4†	5†	5†	4	4
(liquid)	(liquid)	31	67	70	83	100	130	150	70°C.	115°C.
18,000	40,000	> 100,000	—	—	—	—	—	—	—	—
Z_6	A_2†	A_1†	D†	E†	L†	S†	Z†	Z_3†	E†	X-Y
✓	✓	✓	✓	✓	✓				✓	
✓										
✓			✓							
✓										
✓			✓						✓	
✓			✓	✓	✓		✓			✓
✓				✓					✓	
				✓		✓			✓	
				✓		✓			✓	
				✓					✓	
				✓		✓			✓	
				✓		✓			✓	
				✓					✓	
							✓	✓		✓
						✓				
					✓		✓	✓		✓
				✓			✓	✓	✓	✓
					✓					
				✓			✓		✓	✓
					✓	✓	✓			✓
							✓	✓		✓
				✓		✓			✓	
						✓				
						✓				
✓										
						✓				
	✓									

* Available as ARALDITE Resin Solutions for the convenience of the formulator.

† 40% N.V. solution in Butyl "Carbitol."

‡ Used primarily in conjunction with fatty acids to produce esters.

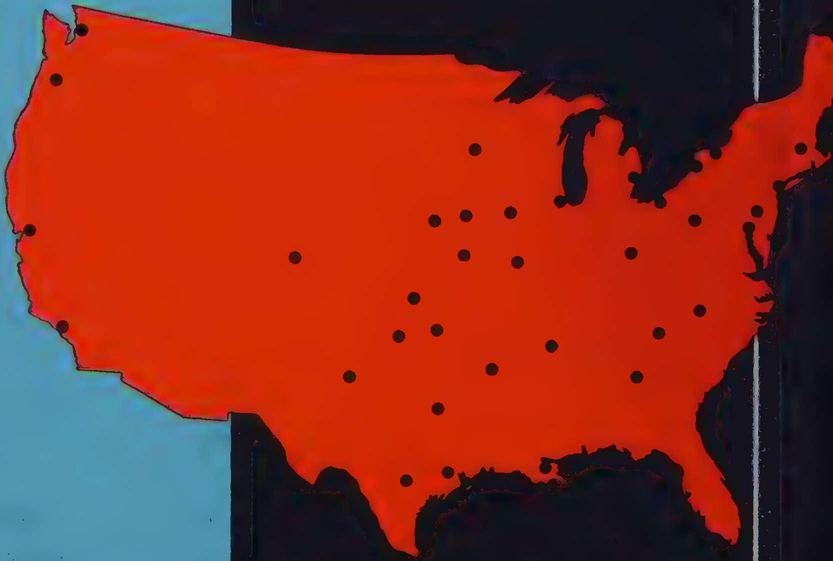
CIBA

FIRST IN EPOXIES

The most up-to-date Technical Service facilities of their kind are part of the modern research and product development laboratories that CIBA has established for evaluating products, methods and end uses. The enlarged production facilities, newly built and now in operation at Toms River, New Jersey, are equipped and staffed for rigid quality control. CIBA will be pleased to supply further information on ARALDITE Epoxy Resins for specific applications.

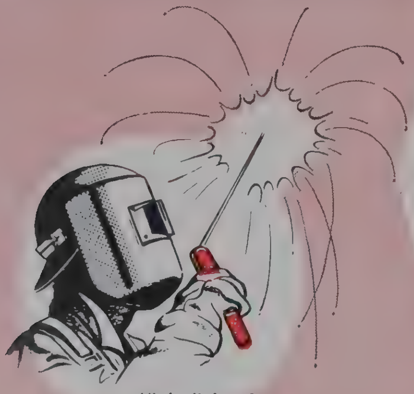
CIBA Products Corporation
Fair Lawn,
New Jersey

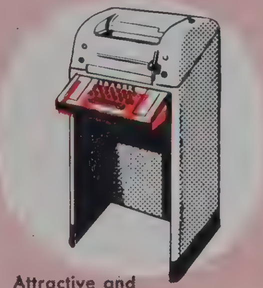
ARALDITE Sales and Warehouse facilities are strategically located from coast to coast to provide prompt and efficient service. In the U.S. and Canada, CIBA produces basic resins only.

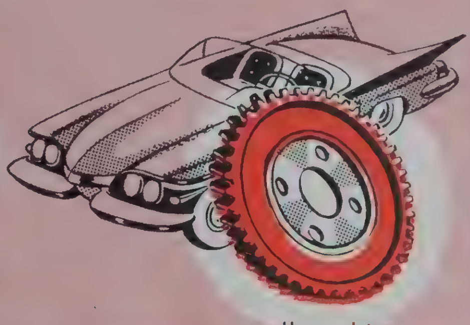


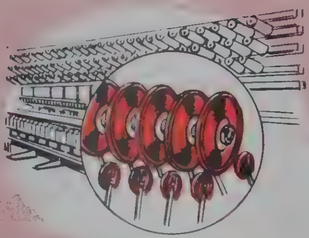
Have *you* put FIBERITE to work yet?

REINFORCED STRENGTH BRINGS NEW QUALITY TO MOLDED PRODUCTS


High dielectric strength


Attractive and indestructible


Heavy duty service


Strong, abrasive resistant, non-static

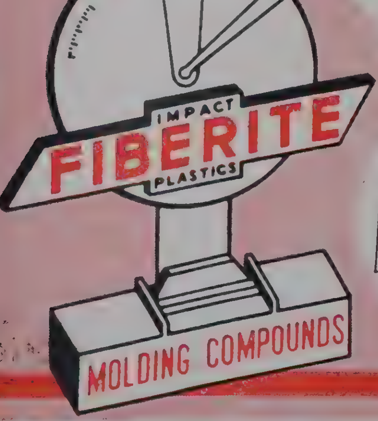
Resilient, durable

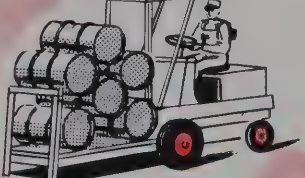
developed to fit today's product requirements

Fiberite reinforced phenolics, melamines and epoxies give you many advantages plus assurance that your molded items will perform under the most adverse conditions. Numerous formulations combining properties essential to specific needs are available right now. New formulations are constantly being developed to meet unusual applications. Specify these highly versatile molding materials for your molded parts.

Does your existing product need more strength? Or is your problem connected with a new product? In any case study the many advantages of reinforced phenolics, melamines and epoxies. Let us show you how Fiberite formulations are used for specific applications requiring dielectric strength, low power loss, impact strength, stability, resistance to high temperatures and many more exacting requirements for industrial and military applications. The records show that with Fiberite you can solve production problems and reduce costs.

Contact your nearest Fiberite Engineering Office listed below or write the factory. Tell us your problem, your plan, your product. Put Fiberite to work for you!




High impact strength

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CHICAGO OFFICE:
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Harrison 7-1164

WESTERN OFFICE:
Riverdale Plastics, 8510 Warner Drive, Culver City, Calif., Texas 0-7733

EASTERN OFFICE:
33 Oakland Ave., Bloomfield, N. J., Pilgrim 8-1233

NEW ENGLAND OFFICE:
Ramapoo Hill Road, Ridgefield, Conn., Idlewood 8-3208

CANADA:
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THE FIBERITE CORPORATION
Manufacturers of Plastic Molding Compounds
Main Office: WINONA, MINNESOTA • Phone 2316

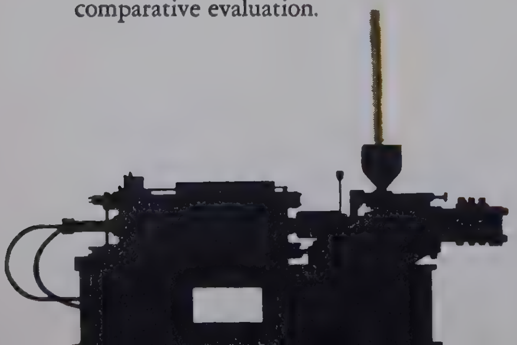
molding, blow molding and extrusion compounds

CATALIN . . . *the gem of plastics.* This trademark and slogan, one of the industry's oldest . . . has symbolized *quality in plastics* since 1928.

CATALIN offers a comprehensive range of plastic raw materials for molding, blow molding and extrusion applications...General purpose, impact and heat resistant grades of POLYSTYRENE, STYRENE ACRILONITRILE COPOLYMERS, STYRENE-METHYL METHACRYLATE COPOLYMERS...Type-6 and 6/6 NYLONS...high, medium and low density POLYETHYLENE...general purpose and high heat resistant POLYPROPYLENE.

These attractive engineering materials offer advantages in weight savings, lower costs, moisture and chemical resistance, toughness, abrasion resistance and many other specific functional qualities that are the everyday concern of the product designer and engineer.

CATALIN welcomes the opportunity to discuss its many formulations with interested manufacturers. Complete physical properties charts are available for comparative evaluation.



Catalin

POLYSTYRENE

general purpose, impact and heat resistant grades

STYRENE ACRILONITRILE COPOLYMER
STYRENE-METHYL METHACRYLATE COPOLYMER

APPLICATIONS

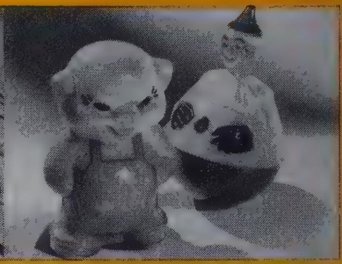
wall tiles

decorative panels

packaging

vacuum formed products

tool handles



toys

housings

furniture legs, drawers

PROPERTIES: CATALIN POLYSTYRENE and STYRENE ALLOYS offer outstanding electrical, mechanical, thermal and chemical properties with good processing characteristics. Of particular interest to those requiring a tough material with excellent clarity, heat resistance, weatherability and light-stability is CATALIN STYRENE-METHYL METHACRYLATE COPOLYMER.

Catalin Corporation of America
One Park Avenue, New York 16, N. Y.

Catalin

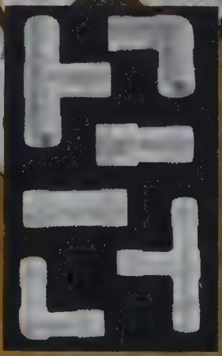
Catalin

TYPE 6 and TYPE 6/6
NYLON

a wide range of grades for all applications

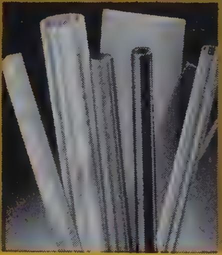
industrial parts

shoe lifts



pipe fittings

rods, tubes, tape



PROPERTIES: Components of NYLON operate efficiently at temperatures up to 250°F. Extreme toughness, high resistance to solvents and chemicals, good bearing characteristics, abrasion resistance and strength in thin sections are but a few of CATALIN NYLON's unique properties. Type-6 is particularly suitable for extrusion and the molding of large parts.

Catalin

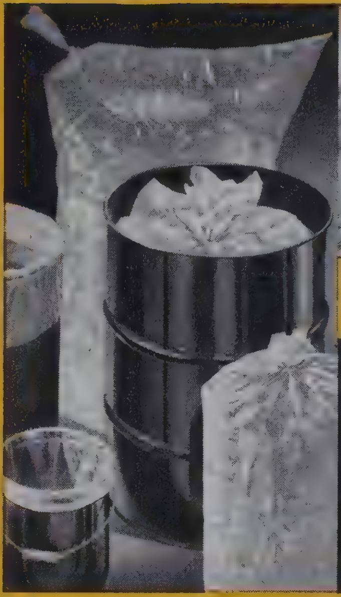
POLYETHYLENE

high, medium and low density formulations

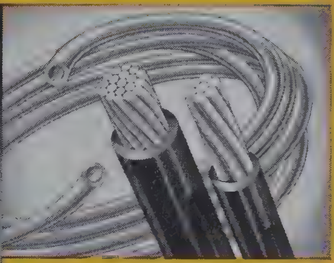
POLYPROPYLENE

general purpose and extra high heat resistant grades

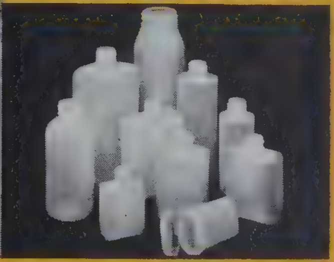
APPLICATIONS



film and sheeting

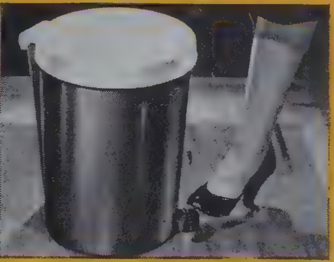


wire coatings, tubing



bottles

toys



pails, laundry baskets

molded flowers

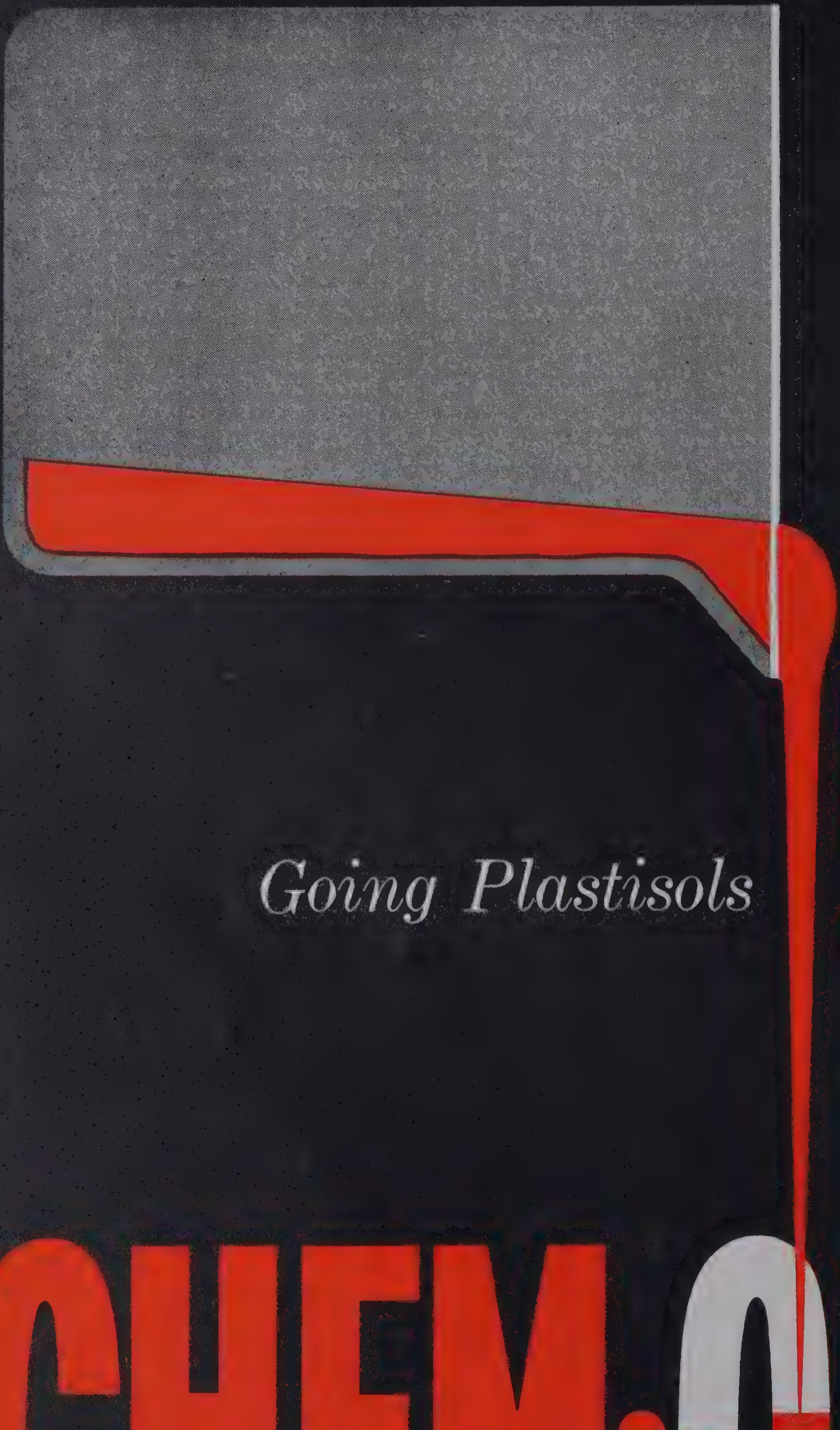
housewares

PROPERTIES: CATALIN POLYETHYLENE and CATALIN POLYPROPYLENE are about equal in chemical resistance and electrical properties. POLYPROPYLENE in comparison to high density POLYETHYLENE is somewhat stronger, tougher and has a higher heat resistance. Both materials possess outstanding processing characteristics in all injection, extrusion and blow molding applications.

In addition to plastics, Catalin products include a wide range of

- urea
- phenolic
- cresylic
- resorcinol
- melamine
- acrylic

RESINS



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A specially formulated polyvinyl dispersion of unlimited potential.
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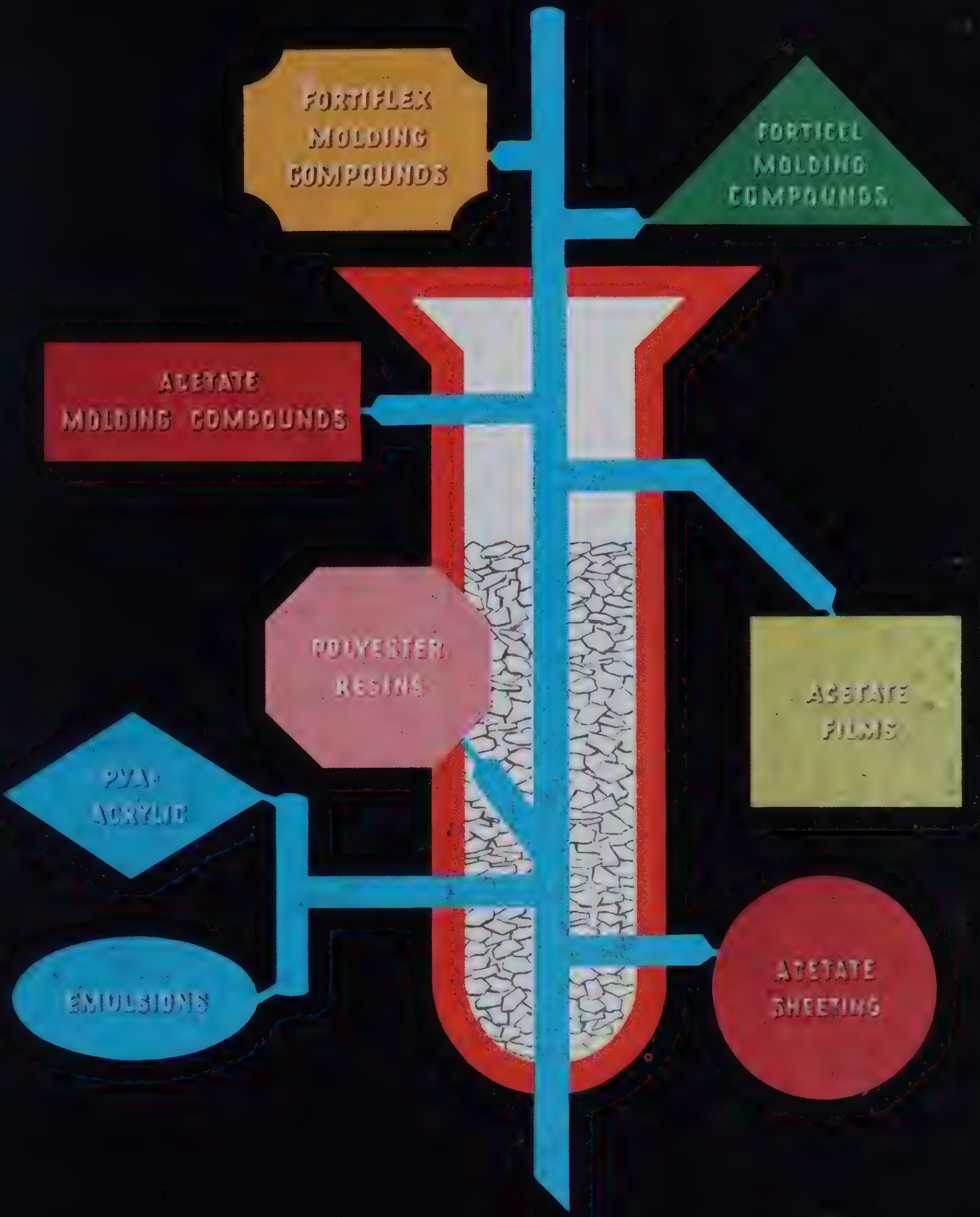

FORTIFLEX MOLDING COMPOUNDS
FORTICEL MOLDING COMPOUNDS
ACETATE MOLDING COMPOUNDS
POLYESTER RESINS
ACETATE FILMS
PVA-ACRYLIC
EMULSIONS
ACETATE SHEETING

Celanese

PLASTICS

FORTIFLEX... A high-density,

Fortiflex A is a series of linear polyolefins, produced by a low-temperature, low-pressure method. The high crystallinity of Fortiflex A (93% compared to 65% for conventional polyethylene) results in superior physical properties. Fortiflex A is a rigid, tough, heat-resistant thermoplastic. Molded parts can be sterilized at temperatures up to 250°F. Fortiflex A can be molded with relative ease into parts having a lustrous finish and good chemical resistance. The material has extremely low permeability to liquids and gases, and its tensile properties are excellent.

Fortiflex A is available in both natural and colored molding powders. Five formulations provide a wide flow range:

FORTIFLEX A-20 possesses the highest impact strength, stress cracking resistance and low-temperature strength of the series. It requires somewhat higher process temperatures. Recommended for extrusion, calendering, blow molding, or injection molding of very small parts requiring maximum physical properties.

FORTIFLEX A-70 is a general-purpose resin. Recommended for injection molding of small parts with limited surface area. This resin is also suggested for extrusion, calendering, blow molding and as a rubber compounding additive.

FORTIFLEX A-250 is used for intermediate-sized injection molded articles where better moldability and improved surface finish are required. Also suited for the extrusion of film.

FORTIFLEX A-500 possesses the best moldability for large-area moldings and applications where maximum processability is required.

FORTIFLEX A-800 is designed primarily for use as a blending component with conventional polyethylene. It offers substantially improved flow characteristics and has reduced impact strength as compared to other resins in the Fortiflex A series. It is suggested for use in blends, single-use containers, or items requiring low

PHYSICAL PROPERTIES RELATED TO MELT INDEX

Property	Units	ASTM Method	A-20	A-70	A-250	A-500	A-800	B50-20	B50-80 to B50-500
Melt Index	—	D1238-52T	0.2	0.7	2.5	5.0	8.0	0.2	0.8-5.0
Heat Distortion Temp., 66 psi.	°F.	D648-56	185	185	180	180	180	170-175	170-175
Impact Strength(1), Notched Izod(2)	ft. lb./ in. notch	D256-54T	23	18	13	3	0.7	7	5-1
Tensile Strength, 0.2 in./min.(3)	psi.	D638-52T	3700	3600	3500	3300	3300	3200	3100
Elongation, 0.2 in./min.(3)	%	D638-52T	28	25	18	13	13	30	25-18
Environmental Stress Cracking Resistance, F_{50} Value	hr.	Bell Lab.(4)	190	30	6	3	—	2000	(5)

PHYSICAL PROPERTIES NOT RELATED TO MELT INDEX

Property	Unit	ASTM Method	Fortiflex A	Fortiflex B50
Density	g/cc.	D792-50	0.96	0.95
Highest Use Temperature(6)				
Continuous	°F.	—	180	—
Intermittent	°F.	—	225	—
Softening Temperature(7)	°F.	—	260	255
Stiffness in Flexure	psi	D747-50	140000	100000
Hardness	Rockwell R	D785-51	40	40
	Shore D	D676-49	65	64
Mold Shrinkage(8)				
Length	in./in.	—	0.010-0.030	0.010-0.030
Width	in./in.	—	0.010-0.025	0.010-0.025
Flammability	in./min.	D635-44	1.0	1.0
Water Absorption, 24 hr. at 77°F.	% gain	D570-54T	< 0.01	< 0.01
Refractive Index	$^{n}D25$	D542-50	1.54	1.54

CHEMICAL RESISTANCE OF FORTIFLEX A

Chemical	Value*
ACIDS	
Acetic Acid, glacial	0.7
Oleic Acid	0.7
Sulfuric Acid 98%	0.0
Nitric Acid 70%	0.3
BASES	
Sodium Hydroxide 50%	0.0
Ammonium Hydroxide 28%	0.0
SOLVENTS	
Acetone	0.7
Carbon Tetrachloride	14.0
Ethanol	0.1
Ethyl Acetate	2.3
Methyl "Carbitol"	0.1
MISCELLANEOUS	
Water	0.0
Gasoline	6.0
Lubricating Oil	0.6
Brake Fluid	0.2

*% Increase in wt. after 30 days immersion at 80°F. Sample specimens were 1"x¼"x⅛" 0.035.

TYPICAL ELECTRICAL PROPERTIES OF FORTIFLEX A AND FORTIFLEX B-50

Property	Units	ASTM Method	Frequency (cycles per sec.)	Value
Dielectric Strength (short time)	volts/mil	D149-55T	—	500
Volume Resistivity	ohm cm.	D257-54T	—	6×10^{15}
Dielectric Constant	—	D150-54T	1×10^3	2.35
			1×10^6	2.36
Dissipation Factor	—	D150-54T	1×10^3	0.0002
			1×10^6	0.0003
Loss Factor	—	D150-54T	1×10^3	0.0007
			1×10^6	0.0007

GAS PERMEABILITY OF FORTIFLEX A

Gas	Units	Value*
Carbon Dioxide	(cc. cm./sec. cm.^{2} cm. Hg.) x 10^{-9}	0.21
Hydrogen		0.20
Oxygen		0.07
Helium		0.15
Ethane		0.15
Natural Gas (ca. 99% Methane)		0.07
Freon		0.06

*Determined on 2 mil blown tubing by method of Baubaker and Kammermeyer, Ind. Eng. Chem. 45, 1148 (1953).

FOOTNOTES

(1) Impact values observed on injection molded bars should not be considered indicative of practical impact values for molded items where other factors affect the impact value. While its impact value will be sufficient for most uses, Fortiflex B should be evaluated for each specific application.

(2) Injection molded specimens, ⅛"x½" cross section, notch in the ⅛" face. A-20, A-70 and A-250 specimens did not break. A-500 and Fortiflex B50 copolymers exhibited partial or hinged breaks.

(3) Injection molded Type I specimens, ⅛" thick. Tensile strength and elongation data recorded at the first yield point.

(4) ASTM Standard on Plastics, Issue of February, 1957. Appendix, page 831 — Proposed Method of Test for Environmental Stress Cracking of Ethylene Plastics.

(5) Fortiflex B50-80 has an environmental stress cracking resistance F_{50} value of 160 hrs.

(6) Highest use temperature depends on part design, molding and service conditions, special formulations are available for continuous use at higher temperatures up to 212°F

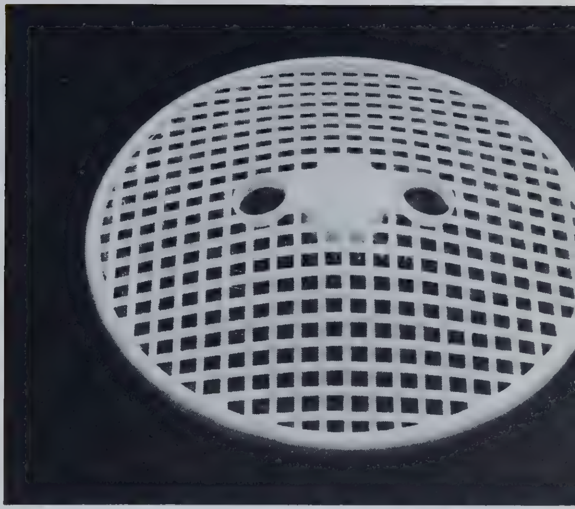
(7) Method of Karrer et al, Ind. Engr. Chem., Anal. Ed. 2, 96 (1930).

(8) Mold shrinkage depends on part design and molding conditions.

impact strength such as certain toys and novelties. Not recommended where stress cracking is a problem.

FLAME RESISTANT FORTIFLEX. In order to meet the increasing demand for flame resistant materials, Celanese is offering specially formulated variations of Fortiflex A-70, A-250 and A-500. These flame resistant Fortiflex formulations are opaque, self-extinguishing high-density polyethylenes with a specific gravity of 1.04. Their stiffness, hardness and tensile strength are approximately the same as the standard resins'. However, heat distortion values under 66 psi are slightly lower and impact strength is somewhat reduced. Burning rate or flammability is reduced to the point where they can be classified as non-burning materials under ASTM D-635-44.

Applications for Fortiflex A include: housewares and appliances, electrical and automotive parts, filaments for textiles and rope, packaging materials, bottles and containers, toys, industrial parts and protective helmets.



LINT SCREEN for gas and electric dryers has rigidity, toughness, heat resistance. Smooth, lustrous surface of Fortiflex handles laundry gently.

FORTIFLEX B

Fortiflex B, a group of linear copolymers, is the latest in the Fortiflex family. It was developed to provide special advantages. With the addition of Fortiflex B, the Fortiflex series provides a family of resins with an extremely broad range of properties which make it possible to upgrade many applications now employing other thermoplastics while it also opens up many new fields of application for plastics.

Fortiflex B is an excellent injection molding plastic and provides outstanding stress crack resistance. Processability of Fortiflex B resins is somewhat improved over the Fortiflex A series resins when compared with them on a melt index for melt index basis. Thus, cycle time for a given part is somewhat less for these resins as compared to Fortiflex A, since their cold point and viscosity are lower. The improved flow properties result in faster fill and freeze times.

In tests under a static load, properly oriented filaments of the new polymer show reduced tendency to stretch. Under sustained stress they resist failure up to ten times longer than previous polyolefin filaments.

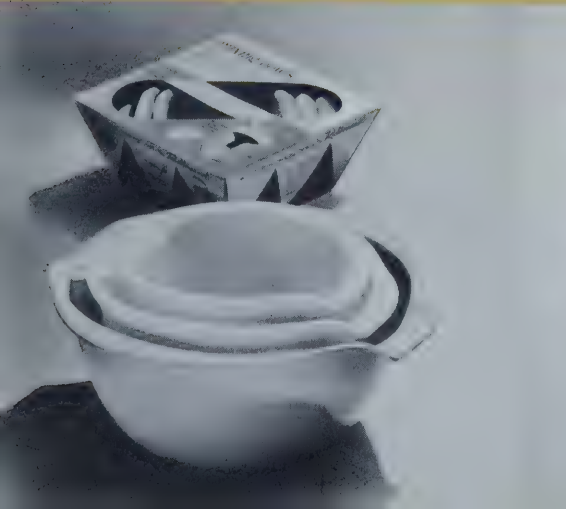
The Fortiflex B series is recommended for end-uses such as filaments for rope and outdoor furniture webbing, wire covering, blown bottles and containers, paper coating, film, and pipe.

Possible applications for injection molding are: containers for stress-active agents, drum plugs, fittings and couplings, thin-walled moldings, large area moldings, insert moldings, bottle caps and closures.

New prospects for the blow molding of bottles and hollow-ware have been opened to molders by the Fortiflex B series.

VACUUM-CLEANER HOSE armored with Fortiflex filament is strong, light in weight, abrasion resistant. Filament has high tenacity, low elongation.

COLORFUL HOUSEWARES molded of Fortiflex have lustrous surface and high impact strength. They are rigid, tough, light in weight . . . withstand boiling heat and freezing cold.



MASSIVE, HEAVY-DUTY DUMP TRUCK molded of Fortiflex has high strength and rigidity. Large toy moldings and weight-bearing toys are made possible by Fortiflex.

G. E. VAPORIZER uses unbreakable, lightweight bottle which holds nearly a gallon of water. Fortiflex is an outstanding material for blow molding hollow shapes.

FORTICEL cellulose propionate

Forticel is distinctive among thermoplastics for its excellent *balance* of desirable properties. Its combination of toughness and good flexural strength is unique among cellulose ester plastics. Moreover, the high impact strengths of Forticel occur at moderate plasticizer levels, where its other good characteristics, such as dimensional stability and stiffness, are also optimum. No other cellulose plastic of similar general properties has less humidity expansion. The low water absorption of Forticel results in stability against warpage. Forticel has considerably more resistance to weathering than cellulose acetate and is very similar to cellulose acetate butyrate in this respect.

Forticel is exceptional for the luster of its molded surface, which is obtainable on a fast cycle—in some items the fastest of all the cellulosics. A free flowing plastic, it can be injection molded with great ease and lends itself to restricted gating and complicated mold layouts. Its superior flow insures practically invisible weld lines where two streams of plastic meet in the die. Forticel eliminates problems of flow around mold pins. Finished parts of Forticel are free from objectionable odor, so that Forticel is often used for personal items such as mascara brushes and containers, toothbrushes, toys, and telephone headsets.

Forticel is produced in four series of formulas offering different flow ranges and end-use advantages. Forticel is available in a range of transparent, translucent and opaque colors. Applications include: pens, telephone housings, automotive parts, optical frames, business machine keys, vacuum cleaner attachments, handles, small equipment housings.

CHEMICAL RESISTANCE*

Reagent	Effect
ACIDS	
30% Sulfuric	No change
30% Sulfuric	No change
10% Nitric	Surface attacked
5% Acetic	No change
10% Hydrochloric	No change
Oleic	No change
BASES	
10% Sodium Hydroxide	Sl. surface attack
1% Sodium Hydroxide	No change
10% Ammonium Hydroxide	Sl. surface attack
2% Sodium Carbonate	No change
ORGANIC SOLVENTS	
Carbon Tetrachloride	Swollen
Gasoline (white)	No change
AQUEOUS SOLUTIONS	
Water	No change
10% Sodium Chloride	No change
3% Hydrogen Peroxide	No change

*ASTM method D-543

ELECTRICAL PROPERTIES*

Dielectric Constant at 10^6 cycles	D-150-54T	3.0 to 3.5
Power Factor at 10^3 cycles	"	0.010 to 0.011
Power Factor at 10^6 cycles	"	0.017 to 0.020
Insulation Resistance (megohms)	D-257-54T	2×10^6
Dielectric Strength (volts/mil)	D-149-55T	800 to 1,500

*Measured at 73°F. and 50% R.H.

The electrical properties of Forticel are considerably more constant over a humidity range than those of cellulose acetate because of much lower water absorption.

TYPICAL PHYSICAL PROPERTIES OF FORTICEL

		Flow Temperature	Specific Gravity	Rockwell Hardness	Impact Strength (Izod)	Heat Distortion Temp.	Tensile Strength	Elongation	Flexural Strength	Water Absorption	Molding Cold Point
	Unit	°C		R Scale	ft. lb./in. notch	°C	psi	%	psi	%	°F
	A.S.T.M. Test	D569-48	D792-50	D785-51	D256-54T	D648-45T (264 psi)	D638-52T	D638-52T	D790-49T	D570-54T	Relative
JM SERIES	A-(H2)	179	1.24	106	1.2	70	5,900	63	10,000	2.00	425
	B-(H2)	176	1.23	102	1.4	67	5,400	60	9,400	1.90	415
	A-(H)	174	1.22	97	1.6	65	4,900	55	8,900	1.80	405
	B-(H)	171	1.22	89	2.4	63	4,600	55	8,500	1.80	390
	A-(MH)	168	1.21	82	4.2	61	4,300	54	7,800	1.70	380
	B-(M)	165	1.20	70	8.5	59	3,900	54	6,600	1.70	360
	A-(MS)	162	1.20	62	10.5	57	3,500	54	6,200	1.70	340
	B-(MS)	159	1.19	53	10.8	56	3,300	53	5,800	1.70	325
	A-(S)	156	1.19	43	11	55	2,900	52	5,200	1.60	310
	B-(S)	153	1.19	33	11	53	2,600	51	4,500	1.60	295
	A-(S2)	150	1.19	21	11	52	2,400	50	4,000	1.60	280
	A-(S3)	145	1.18	–15	10	51	1,900	48	3,000	1.60	260
JL SERIES	A-(H2)	183	1.24	100	1.7	70	5,400	50	10,000	2.00	420
	B-(H2)	178	1.23	95	2.0	69	5,000	56	9,600	1.80	405
	A-(H)	176	1.21	90	2.4	67	4,800	58	9,200	1.70	390

TELEPHONES IN COLORS add a bright touch to decor. Forticel provides shatterproof toughness, good dimensional stability, high surface luster.

WESTCLOX "TRAVALARM" comes in lustrous ivory or black. Forticel was selected for its toughness, excellent moldability, freedom from unpleasant odor.

FAMOUS NAMES in pens prefer strong Celanese Forticel for molding bodies and caps to precise, stable dimensions. An example is the Scripto ball point pen.

ACETATE molding compounds

Acetate is a very widely used cellulosic plastic. Economical and versatile, its usefulness extends over a wide range of consumer products.

In toughness, acetate can seldom be matched by any other plastic in its price bracket. It has high impact strength, rigidity, a hard surface, satisfactory dimensional stability for many applications. Acetate is free of objectionable odor, has practically no taste, and has relatively good temperature stability, which permits its use in refrigerators. The XK series is formulated entirely of ingredients considered acceptable for use in contact with foods by the Food & Drug Administration. Dielectric properties are good. The plastic is unharmed by common hydrocarbons such as gasoline, benzene and oils.

Acetate has excellent moldability, and molding temperatures are not critical. The plastic is free-flowing, which minimizes the problem of weld lines, and is recommended for applications incorporating metal inserts. Acetate molds with an excellent surface finish. With the aid of pre-plasticizing machines, heavy parts can be molded in one cavity and family molds can also be used. Acetate is easily fabricated. Parts may be cemented together to give a bond as strong as the original pieces. Formulations can be widely varied in properties by use of various types and amounts of plasticizers.

Acetate is produced in a number of formulations—including flame resistant material in a broad range of flows. It is offered in a practically limitless range of transparent, translucent and opaque colors as well as crystal clear. Applications include: toys, shoe heels, appliance housings, toilet seats, jewelry, tool handles, sun glasses, brush backs.

ELECTRICAL PROPERTIES

	ASTM Method	Units	Typical Formula XM-H3	Typical Formula XFA-H3
DIELECTRIC STRENGTH	D-149-55T			
0% R.H., 25°C.		volts/mil	390	370
50% R.H., 25°C.		volts/mil	350	360
95% R.H., 25°C.		volts/mil	320	340
VOLUME RESISTIVITY	D-257-54T			
0% R.H., 25°C.		ohm-cm.	10^{14}	10^{14}
50% R.H., 25°C.		ohm-cm.	10^{13}	10^{13}
95% R.H., 25°C.		ohm-cm.	10^{11}	10^{11}
DIELECTRIC CONSTANT	D-150-54T			
1 kilocycle, at				
0% R.H., 25°C.			4.4	4.4
50% R.H., 25°C.			5.2	5.1
95% R.H., 25°C.			7.5	7.9
1 megacycle, at				
0% R.H., 25°C.			3.8	3.8
50% R.H., 25°C.			4.5	4.3
95% R.H., 25°C.			6.5	6.5
POWER FACTOR	D-150-54T			
1 kilocycle, at				
0% R.H., 25°C.			.020	.024
50% R.H., 25°C.			.024	.024
95% R.H., 25°C.			.042	.032
1 megacycle, at				
0% R.H., 25°C.			.038	.041
50% R.H., 25°C.			.048	.055
95% R.H., 25°C.			.050	.055
Arc RESISTANCE	D-495-48T			
50% R.H., 25°C.			175	61

ACETATE FORMULA SERIES

Property	Units	ASTM Method	XM SERIES Range S3	XM SERIES Range H7	XL SERIES Range S5	XL SERIES Range H4	XR SERIES Range S2	XR SERIES Range H2	XP SERIES Range S	XP SERIES Range H2	XK SERIES Range MS	XK SERIES Range H4	XFB SERIES Range S	XFB SERIES Range H4
Flow Temperature	°C	D-569-48	125	185	115	170	130	160	135	160	140	170	135	170
	°F		257	365	239	338	266	320	275	320	284	338	275	338
Specific Gravity		D-792-50	1.27	1.30	1.28	1.31	1.27	1.30	1.28	1.28	1.26	1.28	1.25	1.28
Rockwell Hardness	R Scale	D-785-51	40	119	57	120	55	96	50	87	59	108	66	112
Impact Strength (Izod)	ft. lb. / in. notch	D-256-56	5.6	1.2	5.8	1.9	5.0	2.8	5.0	3.2	4.1	2.9	4.2	2.4
Heat Distortion Temp.	°C.	D-648-56	46	74	44	73	50	65	48	61	52	61	50	58
	°F		115	165	111	163	122	149	118	142	126	142	122	136
Deformation Under Load	% change in height —24 hours	D-621-51	37.0	3.0	32.2	4.0	30	13	33	15	6.7	0.2	3.8	1.2
Tensile Strength	psi	D-638-56T	2800	6400	3600	7400	3900	5800	2800	4800	2800	6100	2700	5800
Elongation	%	D-638-56T	52	16	47	16	45	30	50	30	45	33	—	—
Flexural Strength	psi	D-790-49T	2300	11200	4700	11600	4800	8900	2500	7100	5000	10000	6200	11100
Compressive Strength	psi	D-695-54	12000	29000	13800	32500	16200	25700	14000	22500	—	—	14500	27100
Water Absorption	% wt. gain + soluble matter lost	D-570-54T	2.7	2.7	2.1	2.6	2.4	2.6	2.4	2.4	2.3	2.4	4.5	2.8
Weight Loss on Heating	% at 82°C. for 72 hours	D-706-55T	10.8	0.5	8.1	0.7	8.1	3.5	6.0	4.0	6.0	1.2	3.1	0.8

SHOE HEELS molded of Celanese Acetate are tough. They take prolonged pavement pounding, resist breakage, can be nailed without splitting.

TOYS, like this famous doll, can be economically molded of acetate . . . are strong, attractive, colorful, light in weight—a pleasure for children to handle.

TOILET SEATS molded of Celanese Acetate are both sturdy and sanitary. They can be molded in colors to match bathroom decor, are easy to keep clean.

POLYESTER RESINS

Celanese polyester resins are thermosetting liquids which are cured in the presence of peroxide catalysts to stable, infusible solids. Cure can be achieved at low temperatures and pressures down to atmospheric pressure. Tack-free cures can be made at ordinary room temperatures through the use of suitable accelerators.

Celanese polyesters are supplied in viscosities ranging from close to that of water to that of heavy molasses. Generally they are clear liquids, except for the thixotropic formulations. They are 100% reactive and are not dependent on the release of solvent or any volatile reaction product for solidification. When reinforced with fibrous glass cloth, laminates can be produced which often have a better strength-to-weight ratio than steel. The cured resins exhibit excellent resistance to moisture, heat, weathering and most chemicals. Electrical properties are outstanding.

These resins are available in a number of formulations which can be blended to obtain specific properties in the finished product. A full range of thixotropic resins is available for use in hand lay-up on vertical or sloping surfaces where resistance to resin drainage is required. Special sprayable thixotropic resins for use in spray layup equipment, such as the Rand gun or the Hupp gun, are available. A broad line of fast-cycle press molding resins using either styrene, vinyl toluene, or diallyl phthalate monomer is available to cover virtually any requirement for premix, preform, or mat molding. Celanese polyester resins make possible the molding of large and intricate parts by modern fast cycle methods. Applications include: boats, car and truck bodies, corrugated and flat sheeting, machine housings, auto body fillers, tanks and tank linings, swimming pools, ornamental laminates and castings, coatings, electronic parts, and automotive and appliance components.

PHYSICAL AND CHEMICAL PROPERTIES

Laminates Reinforced with 12 plies #181-136 Glass Cloth, According to MIL-R-7575 (USAF) Specifications

Properties at Standard Conditions	Gen. Purpose MR-28C	Gen. Purpose MR-28R	Pre-mix MR-40R	Match die MR-42R
Flexural, Flatwise, Ultimate Strength, psi	61,300	67,400	52,000	75,000
Flexural Tangent Proportional Limit, psi	51,600	32,500	——	——
Flexural Initial Modulus of Elasticity, psi	2.83x10^{6}	2.72x10^{6}	2.8x10^{6}	3.2x10^{6}
Ultimate Tensile Strength, psi	47,000	47,100	37,000	50,000
Ultimate Compressive Strength Edgewise, psi	37,300	37,900	——	——
Water Absorption, 24 hours, percent weight change	+0.1	+0.05	+0.6	+0.2
Rockwell M. Hardness	103	114.2	110	——
Barcol Hardness	67.5	67.0	63	70
Barcol Hardness of Unfilled Casting (25° C)	50-55	50-53	47	50
Specific Gravity	1.88	1.84	1.08	1.15
Resin Content Percent	35.3	37.0	70	70
Viscosity (25° C), Brookfield Viscometer, cp	650	7,000-10,000	2,000-2,500	2,000-2,500

POLYVINYL ACETATE EMULSIONS

Celanese PVAc resin emulsions are milk-white liquids containing 50-55% polymer solids with viscosities ranging from water-thin to extremely viscous. Use of these emulsions eliminates the need for expensive, flammable, odorous, or toxic solvents, since they are water-based. These emulsions offer the advantage of high solids content with good fluidity and have excellent freeze-thaw, mechanical and storage stability. Celanese PVAc emulsions are presently being used in water-based paints, textile finishes, paper coatings, and adhesives. The latest material is a new vinyl-acrylic emulsion CL-203.

PAINTS. Vinyl paints made with Celanese CL-102 homopolymer and CL-202 copolymer PVAc emulsions offer quick drying, low cost, excellent alkali resistance, and good weathering properties. The paints have practically no odor, spread easily, and provide excellent coverage with uniform color and sheen. Celanese PVAc emulsions have set new standards for film clarity and resistance to water spotting. The films also resist sunlight, oils, solvents, greases. The fine particle size of the paint emulsions insures superior pigment binding, eliminates problems of settling in the can, produces tighter, tougher, more closely-knit films.

Applications: Interior flat paints, exterior masonry paints, primers, semi-gloss paints, and industrial metal finishes. Celanese has developed high-gloss formulations and exterior formulations that adhere excellently to chalky surfaces.

TEXTILE FINISHES. Celanese PVAc finishes improve stiffness, durability, strength and wrinkle recovery of woven fabrics. The emulsions can be used in many textile sizing formulations. They are particularly suited for cotton and acetate fabrics, from lightest to heaviest weaves.

PAPER COATINGS. Scuff-proof paper coatings can often improve surface durability by a factor of five. In addition to scuff-proofness, Celanese PVAc finishes upgrade lower-quality papers and form a good base for color coats. They eliminate fire hazards of flammable solvents.

ADHESIVES. PVAc emulsions can be used to make outstanding adhesives for bonding porous materials such as paper and cardboard. The films provide high bond strength, and since the emulsions are water-based, machinery can easily be cleaned. PVAc adhesives are also used for transparent plastic packaging films, acoustic insulation, wood, tile. They are excellent for packaging.

TYPICAL PROPERTIES OF CELANESE POLYVINYL ACETATE EMULSIONS AND FILMS

Properties of Emulsions	CL-100	CL-101	CL-102	CL-202	CL-203
Solids content, %	55±1	55 (Min.)	55±1	55±1	55±1
pH	4-5	4-5	4-5	4-5	4-5
Viscosity, cp.	1000-1500	800-1200	1000-1500	1900-2500	1900-2500
Particle size	medium	large	small	small	medium
Free monomer, maximum %	0.5	0.5	0.5	0.5	0.5
Weight per gallon, lb.	9.2	9.2	9.2	9.1	9.1
Odor	very slight	very slight	very slight	very slight	slight
Borax stability	poor	poor	excellent	excellent	excellent
Settling after dilution					
After 4 days, ml.	4	5	2	1	1
After 13 days, ml.	8	8	3	1	1
Properties of Films					
Clarity and gloss	good	fair	excellent	excellent	excellent
Water spotting	moderate	severe	slight	slight	slight

CELLULOSE ACETATE FILM

Celanese Acetate film is an economical thermoplastic material widely used for its sparkling clarity and ease of processing. Acetate is readily slit, cut, laminated, metallized and printed. High speed and automatic operations may be employed. The plastic can be sealed rapidly with heat and solvents, has a long shelf life, and does not block under most conditions of storage. Available in thicknesses from 0.0005" to 0.002", these materials are offered in a broad range of widths, continuous lengths, and cut sheets in clear transparent.

Celanese Acetate film is manufactured in two types: cast and extruded. These are generally similar in appearance and properties, and can be used interchangeably in many applications. The cast type is a premium quality film outstanding for its perfection of surface, grainless transparency and uniformity. Both film types are produced in a number of formulations to fit specific applications. The excellent physical and mechanical properties of Celanese Acetate films provide many important advantages, such as:

Excellent transparency. Celanese Acetate is crystal-clear and grainless. In packaging it gives product visibility at all times.

Long shelf life. Celanese Acetate retains its original strength over long periods of time, because there is no highly volatile substance to evaporate and make the material brittle. It does not block in storage.

Dimensional stability. Celanese Acetate resists dimensional change even under widely varying atmospheric conditions. This means that overwrapping produces a neat, trim package.

Mold retardance. Celanese Acetate is extremely resistant to the growth of mold, germs, fungi, and other infestations.

Resistance to fogging. Celanese Acetate resists fogging in humid, cold cabinets and will gradually dissipate fog upon rapid changes in temperature and humidity.

High permeability to gases. Celanese Acetate is the most desirable film where good transparency and gas or vapor transmission are required to eliminate high gaseous concentrations. To achieve this effect with most other films, perforation is necessary.

Excellent greaseproofness. Celanese Acetate is highly resistant to most greases.

Printability. Celanese Acetate provides an excellent surface for clear, sharp printed impressions. When printed in reverse it gives added depth, lustre and brilliance to printed impressions.

Ease of fabrication. Celanese Acetate is readily slit, cut, laminated, metallized and printed by simple or high speed automatic operations. It heat seals and solvent seals rapidly.

Applications for Celanese Acetate film include: metallizing, electrical insulation of many types, backing for magnetic recording tape, pressure-sensitive tape, gold stamping foil and decorative ribbons. It is also used in pouches, envelopes and protective covers of all types; multiple layer, three-dimensional illustrations of industrial equipment; over-wraps for packaging of long shelf-life merchandise, as well as fresh produce and bakery products.

TYPICAL PROPERTIES OF ACETATE FILMS*

Formula	**P 903**	**P 904**	**P 907**	**P 911**	**P 912**	**S 600**	**S 650**	**S 602**	**S 652**
Thickness Range, inches	0.00088 0.002	0.00088 0.002	0.0007 0.002	0.00088 0.002	0.0007 0.002	0.0005 0.002	0.0005 0.002	0.0005 0.002	0.0005 0.002
Specific Gravity	1.26	1.31	1.32	1.31	1.30	1.31		1.29	
Tensile Strength, psi	7000-9000	9000-12000	12000-13000	7800-8500	8000-12000	7000-10000	7000-10000	7000-9000	7000-9000
Elongation, %	25 - 35	15 - 25	31 - 42	15 - 25	20 - 30	25 - 50	25 - 50	30 - 55	30 - 55
Softening Temperatures**									
°C.	125	175	150	125	150	150	150	140	140
°F.	260	350	300	260	300	300	300	285	285
Heat Shrinkage, %									
48 hr., 60°C. (140°F.)	1.5-2.5	0.05 0.2	0.1-0.3	1.0-2.0	1.0-2.0	0.1-1.0	0.1-1.0	0.2-1.5	0.2-1.5
48 hr., 116°C. (240°F.)	4.0-6.0	0.9-1.5	1.9-2.6	5.0-7.0	3.5-4.5	2.0-4.0	2.0-4.0	3.0-5.0	3.0-5.0
Moisture Absorption, % 24 hr., 0% RH. plus 48 hr., 90% RH.	4.0	8.5	5.4	3.5	4.5	4.5	4.5	3.5	3.5

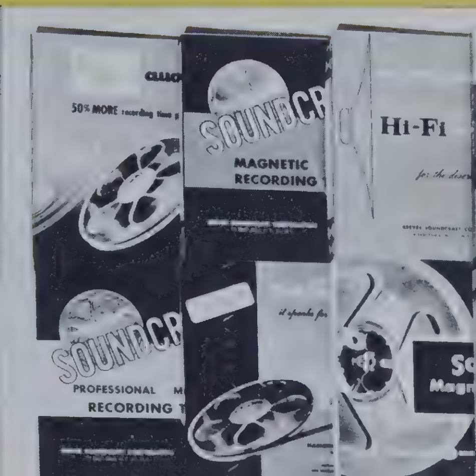
*All tests were made after the samples had been conditioned for 24 hours at 50% relative humidity and 25°C. (77°F.), and the tests were made under the same conditions.

**Softening Temperature—Temperature at which sample becomes limp when heated on a polished copper block at rate of 15°C. per minute. Samples conditioned before testing for at least 24 hours at 50% RH. and 23°C.

FACE SHIELD of Celanese Acetate sheeting demonstrates the clarity and sparkle of the material—and its use as a strong, protective window.

SEE-AND-SELL PACKAGES come in hundreds of shapes, sizes and forms. All sorts of products enjoy a personal showcase on the buying world through Celanese Acetate.

ACETATE BASE RECORDING TAPES eliminate background noise, permit faithful reproduction. They resist stretching even under strong rewind tension.



CELLULOSE ACETATE SHEETING

Celanese Acetate sheeting is a thermoplastic material produced by solvent casting and dry extrusion. The excellent physical and mechanical properties of this sheeting provide many important advantages for a wide range of application These include:

Ease of fabrication. Celanse sheeting can be easily die cut, beaded, punched, stitched, embossed, laminated and cemented.

Excellent thermoforming. Celanese sheeting can be formed by all conventional thermoforming methods. The most popular is vacuum forming.

Toughness. Celanese sheeting has good impact resistance over a range of temperatures. It does not craze or crack under normal stresses.

Rigidity. Celanese sheeting does not become limp or distort under normal high temperature.

Good aging properties. Celanese sheeting does not discolor with age nor become brittle over long periods of time.

Excellent printability. Celanese sheeting can be printed by gravure, letterpress, flexography or silk screen. The excellent surface provides clean, sharp impressions. The sparkling clarity of clear, transparent sheeting provides a lustrous surface to complement quality printing.

Grease resistance. Celanese acetate is excellent for the containment of greases and oils. Approved under MIL-T-21484 for blister packages for bearings.

Colorability. In addition to the clear transparent product, Celanese sheeting is available in a wide range of colors, both transparent and opaque.

CAST SHEETING. Cast sheeting is produced in several formulations in continuous length rolls, gauges 0.003" through 0.020". It is manufactured in clear transparent only, but can be surface tinted with transparent colors. Cast sheeting has a grainless surface of high perfection and is recommended for applications requiring the best optical clarity and greatest rigidity. For special applications cast sheeting can be supplied with a continuous matte surface. Although produced in continuous lengths, cast sheeting can also be supplied in stock size or cut-to-size sheets.

EXTRUDED SHEETING. Extruded sheeting is produced in a wide range of formulations. It is available in continuous length rolls, gauges 0.003" through 0.030". It is also produced in sheets 0.003" through 0.250". The wide range of formulations assures proper selection of a suitable material for a specific application. Certain formulations are compounded entirely of ingredients acceptable to the Food and Drug Administration in connection with food packaging.

Extruded sheeting is manufactured in clear transparent and in an unlimited range of transparent to opaque colors. This sheeting is economically priced and can also be supplied in a variety of finishes. The most common finishes are "as extruded," high polish, and matte.

Applications for Celanese Acetate sheeting include: Transparent containers and protective covers. Contour, blister and skin-type packages. Personal accessories such as costume jewelry, buttons, handbags. Optical frames, face shields, safety goggles, and safety devices. Transparent sheets for printing. Loose-leaf insert folders. Toys and games.

PROPERTIES OF ACETATE SHEETING

Property	Test Method	Units	CAST SHEET				EXTRUDED SHEET				
			.003" Gauge		.010" Gauge		0.010" Gauge				
			L-822	L-864	L-822	L-864	S-700	S-704	S-712	S-729	S-732
Tensile Strength	D882-56-T Method B	psi	12,000	11,500	10,500	11,000	7200	7500	7500	7900	8000
Elongation	Method B	%	38.	40.	41.	45.	68	70	73	67	71
Mullen Burst Strength	—	psi	100	100	300	300	210	210	200	230	230
MIT Fold Endurance	D643-43 Method B	No. of double folds	100	100	10	10	16	20	16	12	16
Elmendorf Tear Strength	—	gms	20	25	110	100	150	160	180	170	160
Edge Tear Resistance	D1004-49-T	lbs/in.					1450	1250	1200	1150	1450
Flatness Test	4 days 25 days	Radius at Curv. inches	2 1	1 1	10 10	5 3					
Flammability Rate	D568-56T	Rating	non-burn.	non-burn.	non-burn.	self-ext. (smothers)	Burning	Self-ext. (drips off)	Burning	Self-ext. (drips off)	Burning
Flammability Rate (SPI)	D1433-58	sq. in./min. in/sec.	— .55	— .75	— .25	1 .30	40 0.55	0 0.35	35 0.45	0 0.35	45 0.60
Tensile Heat Distortion Temperature	at 2% Extension at 50% Extension	°C °C	140 175	135 170	130 165	125 160	105 140	105 125	110 145	110 140	110 150
Heat Shrinkage	48 hr. at 120°F. 48 hr. at 240°F.	% %	0.17 1.3	0.24 2.2	0.22 0.8	 1.7	0.45 4.1	0.10 5.2	0.30 3.9	0.15 3.3	0.35 4.4
Total Light Transmission	D672-45T	%	92	92	91	91	91	91	91	91	91
Haze (Kline-Bowen)	D672-45T	%	2	2	3	3	3	3	3	3	3
Refractive Index	D542-42	(air = 1)	—	—	—	—	1.496	1.498	1.490	1.492	1.490
Specific Gravity	D792-44T at 23°/23°C	—	1.31	1.31	1.31	1.31	1.29	1.32	1.29	1.30	1.29
Water Vapor Transmission	E96-53T 0-50% RH, 73°F 50-100% RH, 73°F 0-90% RH, 100°F	g/24 hr/sq.m.	— 45 200 550	— 40 175 500	— 15 75 190	— 15 65 170	— 30 70 190	— 25 65 170	— 30 75 190	— 25 65 160	— 30 75 200
Moisture Absorption	48 hr, 50% RH, 73°F 48 hr, 90% RH, 73°F	% %	2.0 6.0	1.5 5.5	2.0 5.5	1.5 5.0	1.5 4.5	1.5 4.5	1.5 4.5	1.5 4.5	1.5 4.5
Water Absorption	D570-54T	%	7.5	6.5	7.5	6.5	6.0	6.5	6.5	6.0	6.5

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SEE CELANESE FOR ALL YOUR PLASTICS REQUIREMENTS

We offer technical service for all our plastics. Our experience ranges from the earliest plastics discoveries. A continuous research program is aimed at perfecting formulations and expanding our plastics capabilities. If you have a problem, we may be able to tailor a formulation to satisfy your special needs. Celanese warehouses and facilities at strategic points assure fast deliveries wherever you are located.

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think of
epoxy resins
come to the
people who pioneered
in the development
and manufacture
of them!

epi-cure 855

A New Flexiblizing Type Curing Agent For Improved Resilience

EPI-CURE 855 is a new and modified aliphatic amine curing agent for EPOXY resins, which has resulted from continuing development in the Jones-Dabney Laboratories, where EPOXY resins were developed.

For casting compounds, laminated structural parts, potting and encapsulating EPI-CURE 855 provides several unique advantages. Lower viscosity improves mixing and handling ease, eliminates the use of diluents in many cases, and often lowers the cost of finished compounds.

Complete compatibility with EPI-REZ 510 and similar resins allows faster and more uniform mixing. Bubbles come out faster and preheating and waiting periods before application are eliminated. Now you can handle compounds at lower temperatures with less sweat-out. Longer pot-life permits larger batches and more time for application. After application there is more time for bubbles to surface and break resulting in better wetting.

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The Pioneer Epoxy Resin

When seeking a source of Epoxy Resins come to the people who pioneered in their development and manufacture.

In 1939 Jones-Dabney Co. began a program of deliberate research in the field of EPOXYS. Since that date they have specialized in EPOXY RESINS, maintaining the research leadership in this branch of the industry.

EPI-REZ® meets the most rigid specifications set by the Plastics Industry and is available in drum lots, or 6,000 gallon tank cars. Jones-Dabney's Epoxy Specialists can assure you the most advanced technical information available in the field. No need to look further . . . Come to the people who developed them.

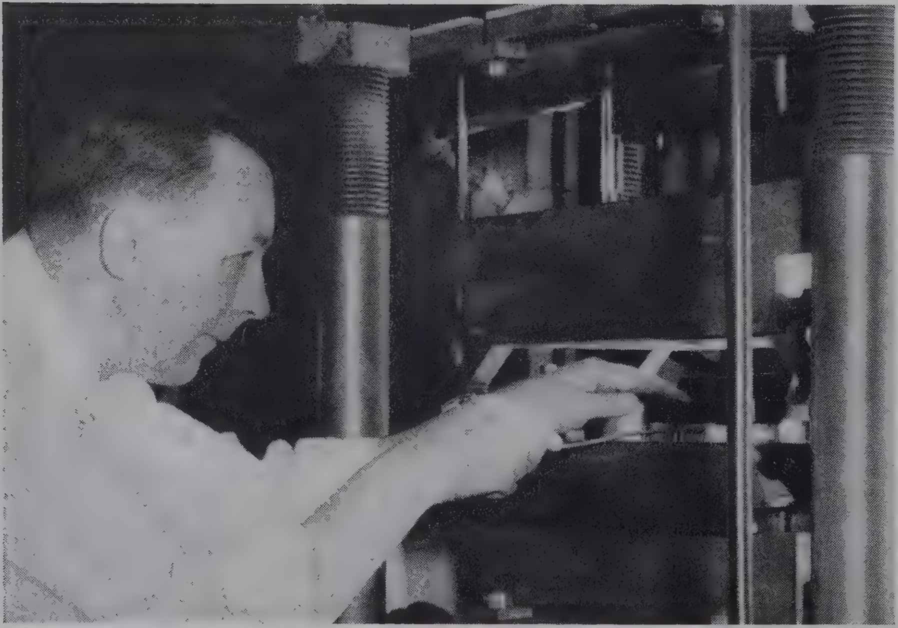
**Pioneers In The
Development and Manufacture
of Epoxy Resins!**

captive or custom –

IF YOU MOLD PHENOLICS,

you benefit from

the G-E value concept



Experienced technical service specialists work with molders and end-users on compound selection, molding techniques. Their job is to help you capitalize the extra values G-E phenolics have to offer.

G.E. believes in the unique values offered by phenolics . . . in the potentials still to be tapped by molders and end-users of these versatile engineering materials.

Where heat resistance, dimensional stability and rigidity are vital, phenolics excel all other plastic materials. That is value. The demand for moldings with these properties is growing. That is potential.

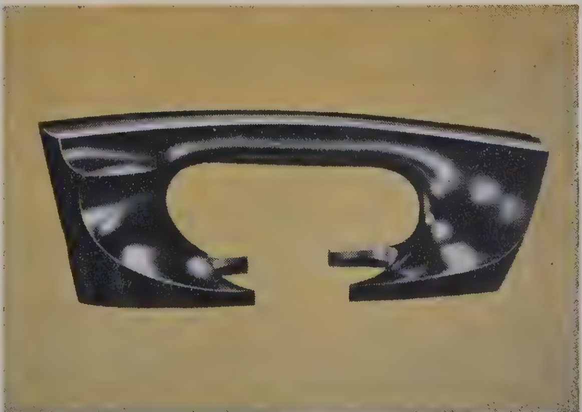
G.E. backs this Value Concept with a two-stage program having a single aim–to help molders realize a bigger profit by giving end-users better product performance.

Stage One is centered on research and development of new phenolic compounds, new applications, new processing techniques. These create new profit opportunities for molders, greater freedom for product designers to make a precise choice.

Stage Two in the G-E program is technical service. Its aim is to help molders find the right compound for each job, then to help them do the job most efficiently, *i.e.*, most profitably. G-E technical service specialists also have another important assignment: to alert their colleagues in research to new or changing needs as these arise.

This is the G-E Value Concept of phenolics. Whatever your interest in phenolics . . . as a molder or end-user . . . put it to work for you; it can add to your profits. For detailed information on G-E phenolics and services, write General Electric Company, Section MPE9, Chemical Materials Department, Pittsfield, Massachusetts.

G-E researchers, alert to need for new combinations of properties, develop compounds to meet them. Broad G-E line provides a single source for virtually any kind of phenolic molding application.

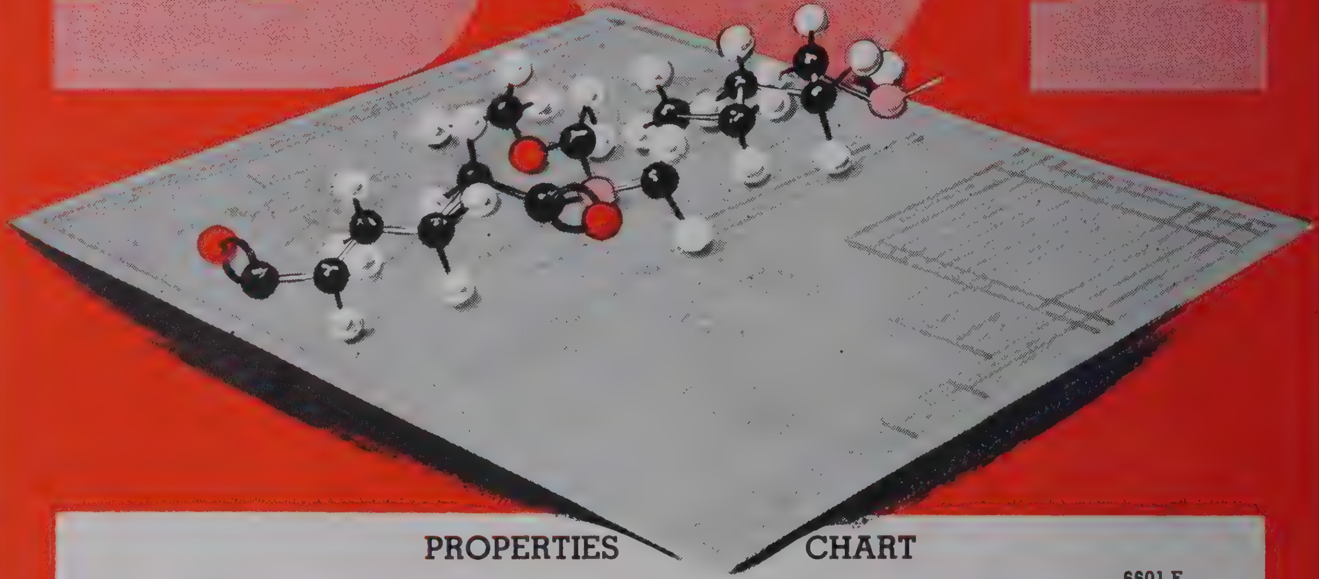


Typical high-specification parts molded of G-E phenolics. Requirements differed widely, but molders found precisely the right compound for each job in G-E line.

Phenolics-first of the modern plastics...first in value

GENERAL ELECTRIC

SERVING YOUR EVER GROWING ENGINEERING REQUIREMENTS WITH NEW AND IMPROVED NYLON RESINS



PROPERTIES CHART

PROPERTY & UNIT	METHOD	800 SERIES	1100 SERIES	6601-F (glass reinforced nylon)
Tensile strength, 73°F. PSI	D638	3,850-6,500	8,500	14,000
Ultimate elongation, 73°F. %	D638	400	100	1.5
Modulus of elasticity, 73°F. PSI	D638	30,000	185,000	1,130,000
Impact strength, Izod. 73°F. FT. LB./IN.	D256	> 16	3.5	2.1
Flexural strength, 73°F. PSI	D790			23,200
Flexural modulus	D790	0.4 x 10^5		9.23 x 10^5
Rockwell hardness	D785		50 (A Scale)	
Linear coefficient of expansion, °F.	D696		0.00010	
Specific heat, CAL./G./°F.			0.58	
Deformation under load, 122°F. 2000 PSI, %	D621	11.1		0.40
Heat-distortion temperature, 264 PSI, °F.	D648			> 518
66 PSI, °F.	D648	129		
Dielectric strength, short-time, V/MIL	D149	342	425	495
step-by-step, V/MIL	D149	244		410
Volume resistivity, OHM-CM.	D257	1.5 x 10^{11}	2 x 10^{13}	5.2 x 10^{15}
Dielectric constant, 60 cycles	D150	9.3		4.0
10^3 cycles	D150	7.7	3.3	3.8
10^6 cycles	D150	4.0		3.4
Power factor, 60 cycles	D150	0.19	0.03	0.017
10^3 cycles	D150	0.13	0.03	0.020
10^6 cycles	D150	0.08	0.02	0.022
Bulk factor	D392		2.2	
Melting point, °F.	D789		367	
Heat of fusion			20	
Water sorption, %	D570	9.5	0.4	1.1
Specific gravity	D792	1.09	1.04	1.32
Clarity		transparent	translucent	translucent to opaque

inquiries invited

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	Description	Tensile Strength	
ASTM TEST		D638	
UNITS		psi @ Yield	psi @ Fail
FOSTARENE® POLYSTYRENE RESINS			
FOSTARENE 20	General Purpose	—	6000-7000
FOSTARENE 94	General Purpose High Strength	—	6800-7600
FOSTARENE 50	Heat Resistant	—	8500-9500
FOSTARENE 122	High Flow	—	6500-7500
FOSTA TUF-FLEX® IMPACT POLYSTYRENES			
FOSTA TUF-FLEX 216	Extrusion Grade High Impact	3500-4500	4100-5000
FOSTA TUF-FLEX 226	Molding Grade High Impact	3000-4000	3500-4500
FOSTA TUF-FLEX 289	Molding Grade High Impact for Shoe Heels	3700	4200
FOSTA TUF-FLEX 324	Medium Impact	4000-5000	4500-5500
FOSTA® NYLON MOLDING AND EXTRUDING RESINS			
FOSTA NYLON TYPE 61	High Stiffness	12100	10100
FOSTA NYLON TYPE 62A-SK	General Purpose	11900	9900
FOSTA NYLON TYPE 64	High Impact	9500	9500
FOSTA NYLON TYPE BK40	Extrusion	11700	11700
FOSTACRYL® STYRENE-ACRYLONITRILE COPOLYMER			
FOSTACRYL	General Purpose	—	10900

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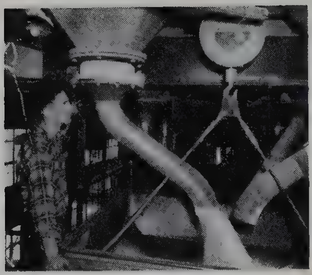
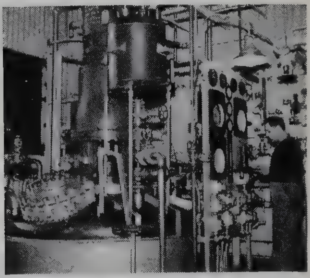
*For unmodified Polystyrenes and Fostacryl flexural strength is reported at failure.

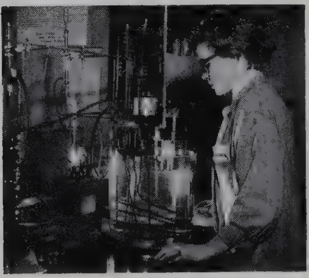
ulations in 4 basic thermoplastics

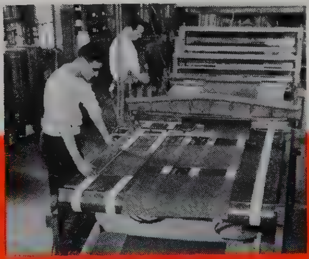
ANICAL PROPERTIES					THERMAL PROPERTIES			PHYSICAL PROPERTIES			
gation		Tensile Modulus	Flexural Strength	Izod Impact	Heat Distortion		Flammability	Specific Gravity	Rockwell Hardness	Moisture Absorption	Mold Shrinkage
638		D638	D790	D256	D648		D635	D792	D785	D570	D955
	Percent @ Fail	psi x 10^5	psi @ Yield*	ft-lbs./in notch	°F @ 66 psi	°F @ 264 psi	in/in.	—	—	Percent	in/in.
	1.5-2.5	4.0-5.0	9000-9500	0.25-0.35	—	170-180	0.5-2.0	1.05-1.07	M70-80	0.04	0.003-0.005
	1.5-2.5	4.0-5.0	9000-11000	0.25-0.35	—	175-185	0.5-2.0	1.05-1.07	M70-80	0.04	0.003-0.005
	1.5-2.5	4.0-5.0	12000-13000	0.25-0.35	—	195-205	0.5-2.0	1.05-1.07	M70-80	0.04	0.003-0.005
	1.3-1.9	4.0-5.0	8000-9000	0.25-0.35	—	160-170	0.5-2.0	1.05-1.07	M70-80	0.04	0.003-0.005
	30-35	3.3-4.0	6100-6700	0.9-1.0	—	165-175	0.5-2.0	1.04-1.06	M35-45	0.05-0.10	0.003-0.005
	35-40	3.0-3.7	5700-6200	0.9-1.2	—	160-170	0.5-2.0	1.04-1.06	M30-40	0.05-0.10	0.003-0.005
	35	3.5	5900-6300	1.0	—	160-170	0.5-2.0	1.04-1.06	M30-40	0.05-0.10	0.003-0.005
	20-30	3.5-4.0	6600-7500	0.5-0.75	—	170-175	0.5-2.0	1.04-1.06	M40-55	0.05-0.10	0.003-0.005
	50-55	4.0-4.4	16000	1.2	390	175	Self Extinguishing	1.14	R118	1.6	0.009
	55-65	3.8-4.2	15800	1.4	385	165	Self Extinguishing	1.14	R112	1.6	0.010
	250	2.0-2.5	9000	2.5	330	150	Self Extinguishing	1.14	R107	2.0	0.011
	100	4.0-4.5	16600	0.9	390	165	Self Extinguishing	1.13	R119	1.6	0.007
	3.1	5.2	15500	0.45	—	198	0.4-0.7	1.075	81	0.25	0.004

ifications for Fosta Nylon, with the exception of water absorption, determined on molded specimens containing less than 0.3% moisture.









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Foster Grant's long experience as a molder, a marketer of plastics products and a supplier of plastics raw materials is a history of steady growth — a history studded with noteworthy achievements in plastics progress.

For example, Foster Grant innovations include the development of the first commercial injection molding machine and the first successful process for commercially molding cellulose acetate.

These and other new molding processes and molding machinery firsts are the outcome of Foster Grant's continuing research and development program conducted in Foster Grant's modern testing laboratories, staffed with a team of outstanding scientists and technicians.

This broad background of practical molding experience, coupled with its modern monomer and polymer plant facilities, enables Foster Grant to offer reliable *Total Marketing Service* for molders and extruders.

FOSTER GRANT COLOR REQUIREMENT PLAN

Here is a plan designed to provide colored polystyrene to large and consistent users at a NEW LOW IN PRICE! In order to reduce manufacturing costs, customers need only provide Foster Grant with a forecast of their colored material requirements. With this information, Foster Grant can then produce and warehouse an accumulated production volume that will assure customers the lowest possible cost and prompt delivery. For more details, write direct to Foster Grant for booklet entitled "The Foster Grant Color Requirement Plan."

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CYMEL®

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Cymel molding compounds fill a variety of industrial and consumer applications—all have basic properties of surface hardness; non-flammability; resistance to heat, boiling water and attack by solvents; color stability; lack of odor or taste, and good electrical properties—for compression, transfer or plunger molding. *Military and Federal specifications are listed on technical data sheets, available on request.*

CYMEL 1077-1079—alpha cellulose-filled – granular or powdered material available in extraordinary surface hardness—rich, lustrous look and feel—excellent chemical resistance—excellent electrical properties, including arc and track resistance . . . *dinnerware, buttons, electric mixer and shaver housings, closures, lighting fixtures.*

CYMEL 592—asbestos-filled—granular material, available in brown only—excellent arc resistance and dielectric strength at elevated temperatures—dimensional stability—resistance to atmospheric extremes . . . *electronic equipment, aircraft and automotive ignition parts, circuit breakers, terminal blocks, switch gears.*

CYMEL 1500—wood flour-filled—granular material, available in brown only—general purpose arc resistant electrical grade material—excellent dielectric strength . . . *watt-hour meter blocks, connector plug inserts, automotive ignition parts.*

CYMEL 1502—cellulose-filled—granular material, available in brown only—particularly good dimensional stability and dielectric strength—excellent insert retention . . . *connector plug inserts, circuit breakers, automotive ignition parts, watt-hour meter blocks.*

CYMEL 3135—glass fiber-filled—coarse-chopped material, natural color—electrical grade, high impact resistance—extraordinary flame resistance—arc resistant—low shrinkage and moisture absorption . . . *heavy duty switch gears, terminal strips and stand-off insulators, sockets and coil forms.*

CYMEL 3136—glass fiber-filled—granular material, natural color—electric grade material with intermediate strength—excellent arc and insulation resistance—extraordinary flame resistance—low shrinkage and moisture absorption . . . *terminal strips and stand-off insulators, sockets and coil forms.*

CYMEL 3020—cotton fabric-filled—chopped cotton, available in black only—electrical grade material with medium impact resistance—very good arc resistance, heat resistance and chemical resistance . . . *terminal strips, circuit breakers.*

CYMEL 404—unfilled—highly translucent, may be tinted before molding—high surface luster . . . *decorative moldings including buttons and jewelry findings.*

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Beetle molding compounds produce marproof, lustrous moldings highly resistant to detergents, oils and greases—they are supplied in powder or granular form and various plasticities to meet specific molding needs in compression molding.

BEETLE is formulated to meet these specifications: Federal L-P-406b, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM). Characteristics: unlimited range of lustrous colors, smooth, hard surface, odorless and tasteless, stain-resistant, wear-resistant, arc-resistant, track-resistant, good dielectric strength, durable. Applications: radio cabinets, stove hardware, wiring devices, electric appliance housings, cosmetic containers, closures, buttons.

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CYANAMID

LAMINAC®

POLYESTER RESINS

Laminac thermosetting resins vary in viscosity, rate of cure, degree of reactivity and degree of rigidity of the cured product – flexible or rigid laminates can be produced by the proper choice of resins – they are clear, nearly colorless liquids – when cured resist heat and chemicals.

LAMINAC 4101 – medium viscosity, general purpose rigid resin developed for compression molding of reinforced trays, boxes, housings and similar products.

LAMINAC 4103 – medium reactivity, resilient resin – ideal for hot-press molding of products required to withstand heavy mechanical abuse – boats, auto bodies and truck cabs.

LAMINAC 4105 – medium reactivity, slightly thixotropic resin – for boat builders and other fabricators using hand lay-up techniques – no sagging, rigid and fast curing.

LAMINAC 4106 – medium reactivity, slightly thixotropic resin–comparable in performance to Laminac 4105 but formulated specifically for use with resin-fiber depositor spray guns.

LAMINAC 4107 – high reactivity, medium viscosity resin – rigid and chemical resistant – suitable for fast high temperature molding as well as for other fabricating methods.

LAMINAC 4109 – medium viscosity, maximum chemical resistance – excellent electrical properties and good hot strength.

LAMINAC 4110 – low viscosity – cures tack free at room temperature – for boats and prototypes.

LAMINAC 4111 – low viscosity, highly reactive resin – maximum chemical resistance and excellent electrical properties – for storage containers, electric and electronic parts.

LAMINAC 4116 – low reactive, general purpose resin – recommended for strength, rigidity and water resistance – for fishing rods, mannequins, radomes, castings (Laminac 4134 may be added for improved resilience).

LAMINAC 4119 – formulated for resistance to mild chemical solutions at temperatures below 120°F – for tanks or storage containers.

LAMINAC 4120 – fast curing, highly reactive, high viscosity resin – suitable for compounding with fillers and with color pastes for obtaining glossy resin rich surfaces.

LAMINAC 4123 – intermediate reactivity, general purpose resin – medium viscosity, useful in either high or low temperature applications for suitcases, chairs, safety helmets.

LAMINAC 4128 – low viscosity, highly reactive resin for hand lay-up or presswork – good hot strength – for aircraft accessories such as junction boxes, fuel tanks.

LAMINAC 4131 – fast curing, excellent moldability – intended for compounding with fillers and fiber reinforcement for premix molding compounds – good fiber-wetting – low density – molded parts have good hot strength and good resilience.

LAMINAC 4134 – low viscosity, flexible resin used in combination with rigid resins to improve impact and shock resistance.

LAMINAC 4146 – for production of self-extinguishing fibrous glass reinforced laminates and moldings – for motor housings under continuous heat, aircraft parts, hot air ducts.

LAMINAC 4192 – for maximum resistance to discoloration on exposure to light – used for the production of flat or corrugated sheeting.

LAMINAC 4202 – high viscosity liquid resin – unusually long catalysed stability – odor free – cures at temperatures above 200°F–for large radomes and aircraft shelters.

LAMINAC 4232 – exceptionally stable at elevated temperatures when properly cured – for production of critical parts that are required to retain strength at high temperatures.

LAMINAC 4233 – similar in characteristics to 4232 plus self-extinguishing properties.

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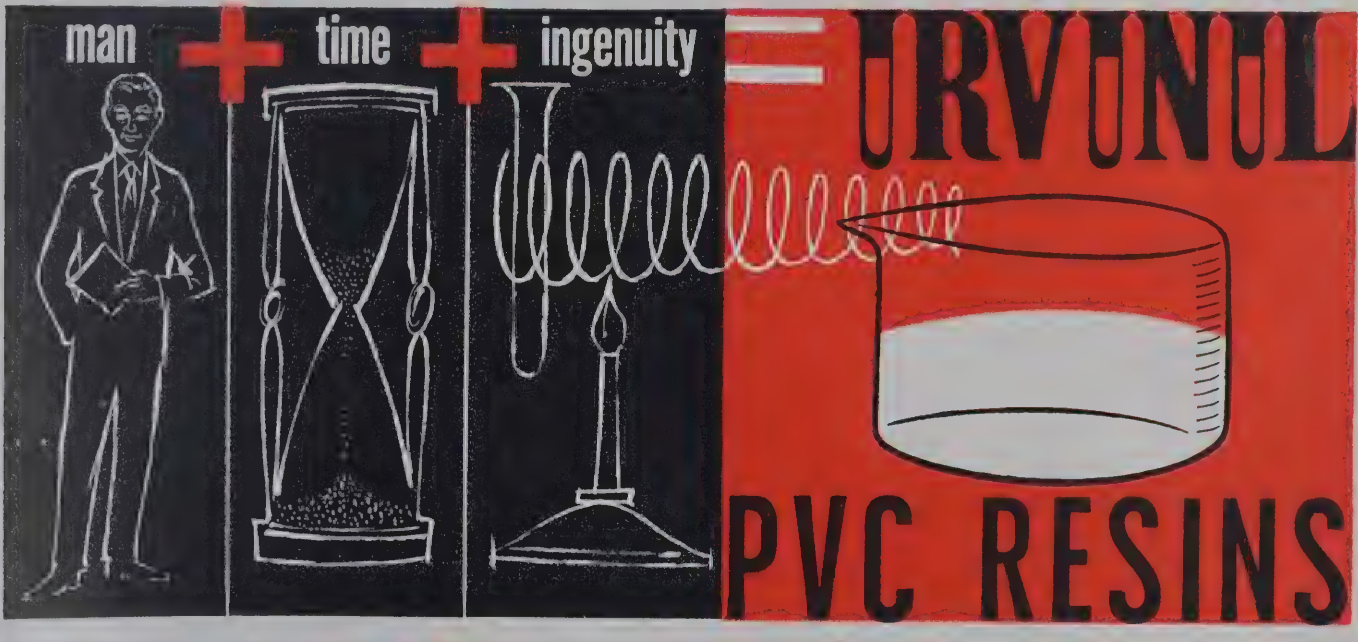

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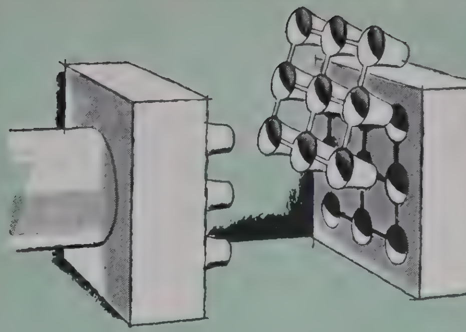
VYGEN 120 A high-molecular-weight, general-purpose resin, ideally suited for dry-blend extrusion operations . . . blended with monomeric or polymeric plasticizers, this resin has an extremely rapid rate of solvation. Vygen 120 has a narrow range of particle size distribution, producing extrusions free of gelled particles.

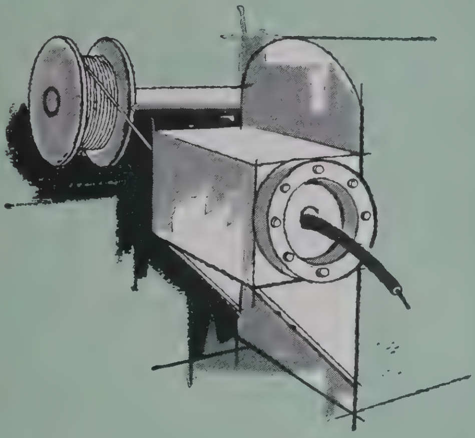
VYGEN 161 An average-molecular-weight resin with extremely high rate of plasticizer absorption. Allows a dry premix in unheated blenders, faster preblending cycles, and faster fluxing on open mills or in a Banbury. Recommended for calendering, extrusion and molding operations requiring high plasticizers-to-resin ratios.

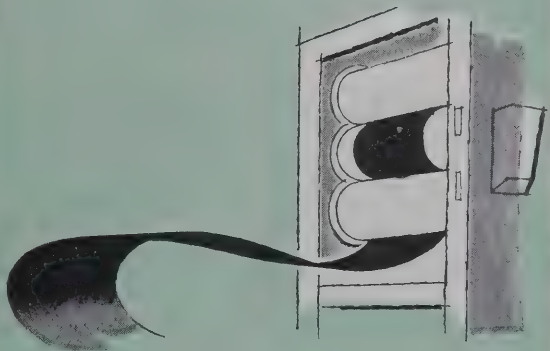
VYGEN 6035 **(COMPOUND)** Approved by Underwriters' Laboratories for Type T, TW, and 60°C applications. May also be used as a primary insulation for other cable constructions and jacketing.

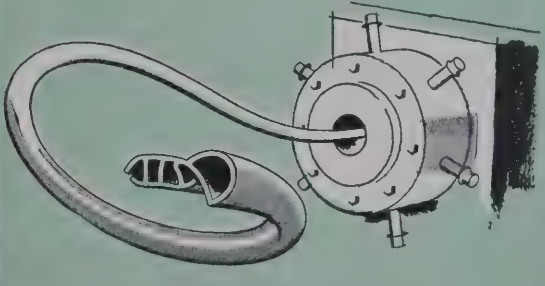
VYGEN 6812 **(COMPOUND)** Approved by Underwriters' Laboratories for Type T, TW, 60°C, oil; and 80°C appliance wire applications as well as UF-NMC cable. It may also be used as a primary insulation for other cable constructions and jacketing.

VYGEN 9221 **(COMPOUND)** Approved by Underwriters' Laboratories for 90 and 105°C applications. Recommended for wire insulations requiring higher heat resistance and good physical properties.


MOLDING


WIRE AND CABLE COATING


CALENDERING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Fibercore

MOLDING COMPOUNDS

PROVIDE
- High impact strength
- Low specific gravity
- Excellent chemical resistance
- Superior electrical properties
- Dimensional stability
- Smooth surface finish

PERMIT
- Complex part design
- Use of metal inserts
- Unrestricted use of colors

Fibercore Molding Compounds are high impact fiber-glass reinforced polyester molding materials. They are available in Standard Chemical, Electrical, and Flame Resistant-Electrical grades and all colors. They can also be specially formulated to meet specific application requirements.

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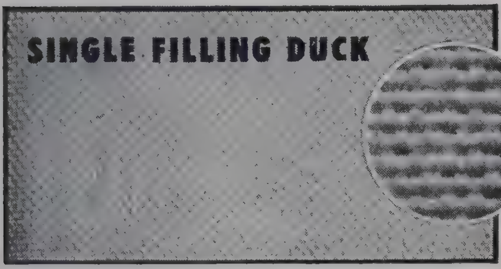
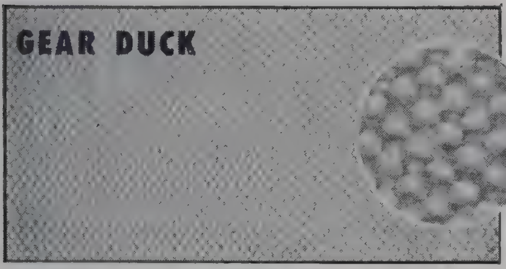
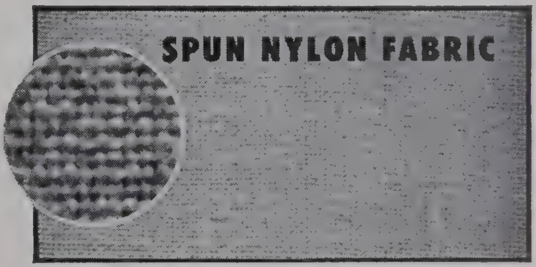
Wellington Sears fabrics insure superior performance for high and low pressure LAMINATING



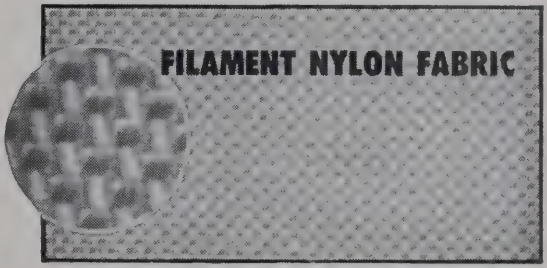
IMPACT STRENGTH... Wellington Sears single filling duck has the right weight and rugged, hard-gripping texture to make an excellent reinforcement for C grade laminates where high impact strength is important, as in the case of certain gears, safety helmets and mechanical parts of many kinds. Available in widths of 29 inches and wider and in weights from about 8 to 15 ounces per square yard.



SHOCK RESISTANCE... Wellington Sears gear duck, like our Superior army duck, is a heavy, rugged fabric, ideal for shock-resistant laminates such as heavy duty mechanical parts in mechanisms subject to sudden starts and stops. Its plied yarn construction contributes high fiber density and freedom from sizing substances that sometimes hinder impregnation. Available in widths of 28½ inches and wider and in weights from about 8 to 15 ounces per square yard. Other Wellington Sears quality cotton fabrics for laminating include drills, Columbus sheeting, single and plied yarn chafers, and numerous special constructions.



GOOD INSULATOR... The nylon staple fibers in this fabric contribute high bonding strength and provide laminates with superior insulation resistance under high humidity conditions, a factor of special importance in items for the electronic and high frequency fields. Wellington Sears staple fiber nylon fabrics are made 28 to 72 inches wide in weights of about 4 ounces per square yard and higher. Also available to laminators are Wellington Sears fabrics of Orlon*, Dacron** and other synthetic fibers.



BALLISTIC PROPERTIES... In this fabric the strength of nylon yarns in filament form provides outstanding impact resistance to low pressure laminates such as wing board liners for military aircraft. Wellington Sears filament nylon fabrics are made in weights of about 2 ounces per square yard and higher, in widths from 28 to 72 inches. They are available in the grey or scoured and heat set for dimensional stability.

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HERCULES

3 NEW PLASTICS

A NEW HERCULES PLASTIC!

TYPICAL PROPERTIES OF HI-FAX

Crystalline melting point, °F.	268
Specific gravity	0.945-0.947
Mold shrinkage, in./in.	0.022-0.028
Water absorption, %	0.03
Heat-distortion temperature (66 p.s.i.), °F.	144-154
Deformation under 2000-lb. load for 6 hr. at 122°F., %	9-16
Hardness, Rockwell R	35-40
Impact, Izod, ft.-lbs./in., notched	1.5-12
unnotched	>32
Tensile yield stress at 73°F., p.s.i.	3450-4500
at 212°F.	1300-1800
Ultimate elongation at 73°F.,%	100-700
Dielectric constant	2.33
Power factor	0.0007

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First of the new Hercules family of plastics, Hi-fax is the Hercules trademark for high-density polyethylene. As produced by an exclusive process, it is superior in many ways to other high-density materials. As a result, Hi-fax offers important advantages to producers in the markets where it now serves. Its superior properties, combined with the outstanding processing economies it affords, yield quality, low-cost products.

Blown containers: Hi-fax is now the standard material by which all plastics used in blown bottles and containers are judged. It provides outstanding performance and economy, especially in products designed to package corrosive materials, offering a high degree of stress-crack resistance coupled with lightweight strength in thin-wall sections.

Industrial shapes: Excellent processability, outstanding low temperature resistance, dimensional stability, and durability in long-term use are characteristic of the many industrial parts now being fabricated with Hi-fax by extrusion and injection molding.

Wire: Wire and cable coatings made with Hi-fax provide a toughness and resistance to abrasion superior to almost any other plastic or rubber.

Pipe: A special pipe grade of Hi-fax yields a low-cost, thin-wall flexible pipe, NSF approved, and setting new standards for quality in flexible piping. Extruders have found it offers many processing advantages over competitive materials.

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Wire and Cable Coatings

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Pro-fax, the bright new name in thermoplastics, is the Hercules trademark for polypropylene. With a high softening point, Pro-fax is dimensionally stable at temperatures as high as 300°F. It has a hard, glossy surface finish, and is available in a full range of opaque and translucent colors. With a specific gravity of only 0.9, *Pro-fax is the lightest of all plastics*, providing a production bonus of many extra parts per pound over other materials in its same price-property class.

Pro-fax for injection molding: Pro-fax is an excellent general-purpose material now finding broad use in such markets as closures and containers, automotive and appliance parts, valves and fittings, housewares, toys, and sporting goods. Pro-fax molds rapidly and well, has only half the shrinkage of high-density polyethylene.

Pro-fax for extrusion: Pro-fax monofilaments are now in growing use in rope, fish nets, seat cover fabrics, outdoor furniture webbing, bristles, pen tubes, and a variety of industrial parts. Extruded Pro-fax sheet provides a splendid structural material for vacuum-forming, thermoforming, and fabrication. Pro-fax film for packaging has sparkling clarity, outstanding toughness, and excellent resistance to permeation.

pro-fax®

TYPICAL PROPERTIES OF PRO-FAX

Crystalline melting point, °F.	333
Specific gravity	0.901
Mold shrinkage, in./in.	0.015 to 0.020
Water absorption, %	0.03
Heat-distortion temperature (66 p.s.i.), °F.	221
Deformation under 2000-lb. load for 6 hr. at 122°F., %	2.0
Hardness, Rockwell R	93
Impact, Izod, ft.-lbs./in., notched	1
unnotched	>17
Tensile yield stress at 73°F., p.s.i.	4970
at 212°F.	1720
Ultimate elongation at 73°F., %	>220
Dielectric constant	2.0
Power factor	0.0003

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Newest new member of the Hercules plastics family is Penton, Hercules trademark for chlorinated polyether. This unusual thermoplastic offers a unique combination of mechanical, electrical, and chemical properties which make it especially useful in tough industrial applications. Penton provides heat resistance well above the normal thermoplastic range, retaining its tensile- and allied-strength properties at elevated temperatures. It is highly resistant to moisture and can be molded to close tolerances. Yet Penton can be readily and economically formed by conventional injection and extrusion methods. Dimensionally stable, it can be precision-molded or accurately machined or fabricated from sheet, block, or rod stock. It also can be applied as a protective coating for metal parts by fluidized-bed or other finishing techniques.

Although newly available as a commercial product, Penton has already firmly established an important place for itself in the corrosion field, where it now serves in valves, pipe and fittings, pumps, meters, coatings and linings for chemical processing systems.

Fabricated Shapes

Valves

Linings and Coatings

Pipe and Fittings

penton

TYPICAL PROPERTIES OF PENTON

Crystalline melting point, °F.		358
Specific gravity		1.4
Mold shrinkage, in./in.		0.004-0.006
Water absorption, %		0.01
Heat-distortion temperature (66 p.s.i.), °F.		300
Deformation under 2000-lb. load for 6 hr. at 122°F., %		1.4
Hardness, Rockwell R		100
Impact, Izod, ft.-lbs./in.,	notched	0.4
	unnotched	>33
Tensile strength at 73°F.		6000
Tensile strength at 212°F.		3500
Ultimate elongation at 73°F.		60-160
Dielectric constant (60 cycles)		3.1
Power factor		0.016

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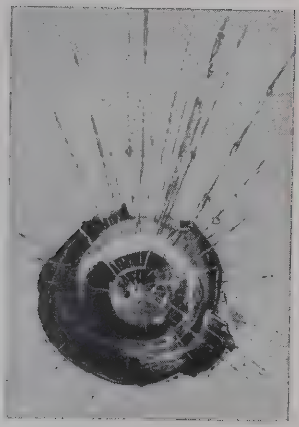

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Foamed Plastics

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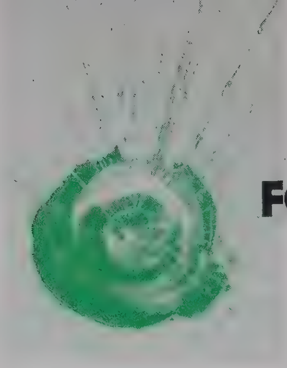

FOAMED PLASTICS

Properties and uses of foams

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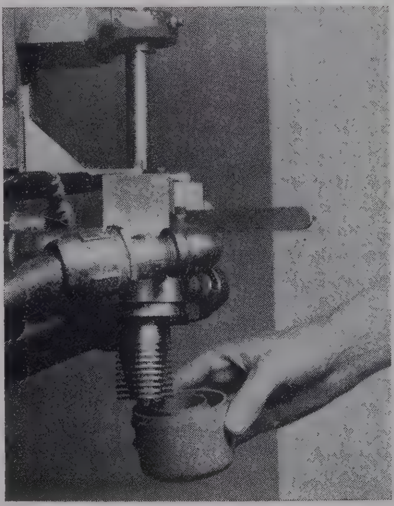
FOAMED POLYURETHANES

By B. Dombrow*

Polyurethane foam is the generic name for a vast number of cellular cross-linked plastics, the structures of which are, in the main, reaction products of hydroxyl-rich materials and polyisocyanates (usually tolylene diisocyanate). The means of blowing can be either one of two types or a combination of them. Carbon dioxide gas generated by the reaction of water on polyisocyanate is the original one. Mechanical blowing by the evaporation of a low-boiling liquid such as a fluorocarbon has been coming into more prominence.

The most important factor in determining the rigidity of a foam is the hydroxyl-rich compound used in its production. This group of compounds includes such diverse chemicals as polyesters and polyethers of varied compositions, molecular weights and branching, as well as comparatively simple compounds such as castor oil. It is not surprising to find such a wide spectrum of rigidity that is potentially attainable for these cellular products. Even within a certain type of rigidity, it is possible to vary the physical properties. Thus, one can make flexible foams which are resilient and also flexible foams which have high energy absorbing properties. In addition, the density of each type can be varied from above 60 lb./cu. ft. to below 2 lb./cu. ft.

FOAMING MACHINE with a special mixing head delivers the exact amount of polyurethane foam formulation required into unit to be filled. (Photo, Nopco)



Hence it is necessary to note that it would be unwise to regard polyurethane foam as a single entity, rather than as a broad class of materials from which it is possible to select individual foams to fit desired applications.

There are many ways in which it is possible to list applications, both actual and potential, for these foams. One way to attempt this would be by means of physical properties. After all, their usefulness is derived from considering them as physical entities. In most applications, more properties than one are involved, but there is usually at least one that is predominant and can be used as a guide in listing applications.

Techniques

In developing automatic methods for producing urethane foams—flexible, semirigid, and rigid—two major problems had to be solved: 1) continuous delivery of components to a mixing chamber and continuous discharge of the resulting blend; and 2) intermittent delivery of the blend so that shots of predetermined magnitude could be introduced to a continuous series of cavities or molds.

Continuous mixing

The many types of problems involved in metering the foam components, pumping them continuously into a mixing chamber, and discharging the blend continuously, were readily solved. Even polyesters of high viscosity can be pumped (using heat, if necessary,

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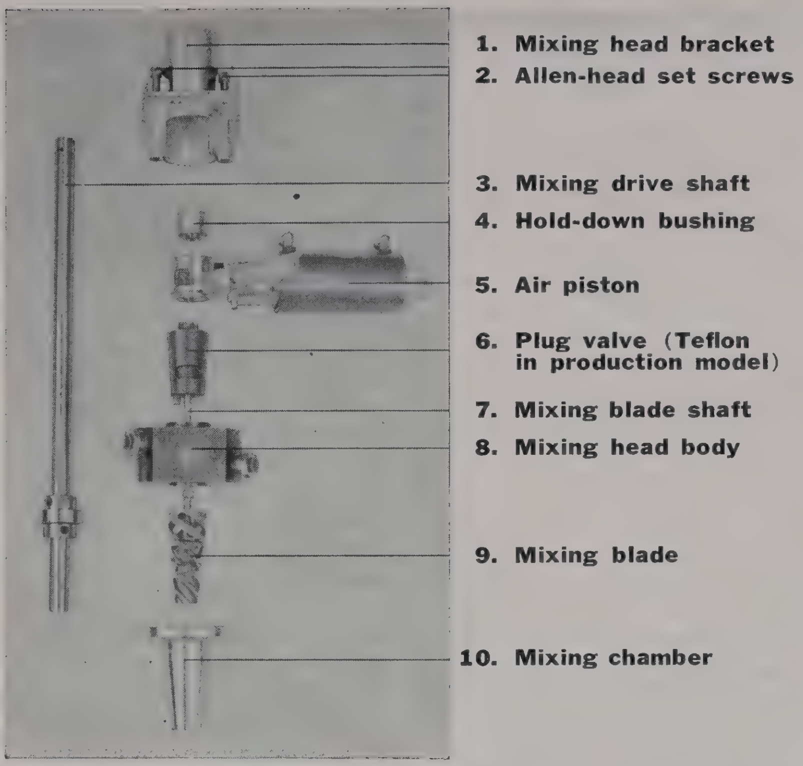
* Director of Laboratories, Plastics Div., Nopco Chemical Co., Inc., 175 Schuyler Ave., North Arlington, N.J.



EXPLODED VIEW of mixing head for foaming machine. (Nopco)

to obtain more easily-handled viscosities) so that constant metering systems can be used. Eventually, equipment was made available that delivered the necessary components to various mixing chambers, out of which flowed continuous foam blends in flexible slab, sheet, or roll form for industrial and household use. This equipment was designed to handle formulations using two or more components.

The foam thus produced by continuous mixing proved superior to that produced by batchwise mixing (see below), both in structure and physical properties, but the technique still did not lend itself to intermittent delivery of the foam so that shots of predetermined magnitude could be introduced at will to a continuous series of separate cavities or molds. For one thing, because of the comparatively large volume of the mixing barrels, large hold-ups were encountered. The pumps could not be stopped until the liquid blend in the barrels was removed or replaced by inert material. This, of course, meant large materials losses. In addition, supplementary waste was caused during the start-up in the period before the foam was thoroughly blended.

Batchwise mixing

Most of the first foamed-in-place urethanes were of the rigid and semirigid type. Because of the lack of equipment, it was necessary to handle these by batchwise stirring. Here, the various foam components are weighed into a container, blended manually with spatulas (or with mechanical blenders if large quantities are involved), and then poured quickly into the desired cavity for foaming. In this manner, single pours of several cubic feet can be successfully made. Larger cavities can be filled by multiple pours, taking care that the first pour has been allowed to set and cool before adding the next pour. This precaution is necessary to prevent the rising foam structure from being disturbed by the second pour to such an extent that it may crack, collapse, show voids, etc.

Because of this problem, the batchwise system is still used for many applications which require the filling of a large cavity through a single opening or a restricted small number of openings. In these cases, a single large batchwise pour can yield a good foam, while the same quantity of material added through the continuous mixing process will not.

Intermittent mixing

Eventually, several techniques were evolved for the intermittent mixing of foam. The most widely used type is one which has developed from basic studies by Du Pont. The fundamental principles are shown in the diagram above. The mixing blade has a 3-stage structure: pump, mixer, and a second pump. This permits the two foam ingredients to be pumped into the middle of the blade, where they are mixed and then pumped out of the bottom. The clearance within the conical mixing chamber is small, so that very little material tends to remain. This simplifies the cleaning problem, and makes for quick blending equilibrium.

The combination of accessories represented by the mixing head body, the plug valve, and the air piston is the heart of the intermittent delivery mechanism. The air piston is used to turn the plug valve quickly within the mixing head body. These two units act as a double 3-way valve. In one position, the two components are circulated through separate lines so that thermal equilibrium can be insured before use, thus enabling the pumping equipment to operate without delivering material to the mixing blade. In the second position, the circulation is cut off and the two components are fed to the mixing blade and its chamber. By means of a timing device, the air piston can activate the plug valve for a predetermined time period so as to discharge a fixed charge whose magnitude is regulated by a timed rate of pumping. Thus, two-component systems can be used, with good temperature control and metering rates. Formulations of component ratios from 97:3 to 50:50 have been a success.

As mentioned above, the problem of laying foam on foam is very acute. In many cases, the batch method is the only solution. In the case of continuous production of slab stock, the liquid blend is poured downward onto a moving belt while the mixing head is moved traverse to the direction of the belt. In this manner, the foam liquid is placed alongside and flows into, but not on top of, the

(*Continued on p. 292*)

A questionnaire sent by the Editors of MODERN PLASTICS ENCYCLOPEDIA ISSUE to suppliers of foamed plastics elicited information on which was based the following run-down on new developments and new applications in the field.

VINYL FOAMS

Cushioning continues to stand out as major market for vinyl foam. At the 1959 Chicago Furniture Show, more than 50 pieces of furniture appeared with molded vinyl foam cushions (Vinylfoam, Union Carbide Plastics). Among other properties, the foam shows outstanding resistance to fire, oxidation, and hardening. Important savings are also involved. For example, International Furniture, Div. Schnadig Corp., Chicago, Ill., reports that a molded vinyl foam cushion (produced by Union Carbide Plastics' Elastomer process), measuring 24 by 24 by 5¼ in., costs $5.00, compared with $6.50 for a rubber latex cushion of the same dimensions.

• • • • •

Blown vinyl film is under experimentation by Naugatuck Chemical Div., U. S. Rubber. Celogen (a blowing agent produced by Naugatuck) is compounded into the film. The film can be blown at once or it can be shipped unblown and expanded at a later time. One of the possible uses for the material is in wall-coverings with a soft, luxurious feel.

• • • • •

A vinyl chloride based coating formulated for use as a hot dip foam plastisol (Sterilkote Plastisol Series No. 400) and one formulated for use as a spray foam plastisol (Series No. 410) have been made available by Bradley and Vrooman. Supplied as free-flowing liquids with stable viscosity properties, they will convert to tough, resilient, abrasion-resistant, inert foam protective coatings that have excellent heat and light stability.

• • • • •

A fire-resistant vinyl foam recommended for use in the transportation field is being sold (Fed-foam, Federal Industries, Div. Textron Co.). The foam is ideal for the "do-it-yourself" market since it can be cut or trimmed to any desired size with a sharp knife or razor blade. In common with other vinyl foams, it has excellent tensile and tear strength, resists temperature extremes and climatic conditions.

• • • • •

A new vinyl foam (Cipco Foam, Carolina Industrial Plastics Div., Essex Wire Corp.) is extruded in continuous lengths with a uniform small cell structure and a controlled mixture of open and closed cells. Its cellular construction results in a material which does not bottom under sudden impact. Other suggested uses, in addition to wire coating, include automotive windlacing around doors, insulation at bottoms of storm doors, bumper strips on garage doors, and seals for uneven surfaces.

URETHANE FOAM

Predictions have been made (by J. D. Mahoney, Mobay Chemical Co.) that 70 million lb. of basic chemicals will be produced by the fast-growing urethane industry in 1959. Approximately 40 million lb. of urethane raw materials were produced in 1958. Major markets will include: cushioning for home use and in transportation; urethane foam mattresses; protective packaging of optical instruments and missile components. In the past year, such new developments as the one-shot polyether foaming system have contributed to production economies. Based on the use of a new combination of catalysts, this system eliminates much of the premixing required in earlier methods and simplifies curing requirements.

• • • • •

The exteriors of two 80,000 gal. TDI storage tanks at Mobay's plant in New Martinsville were recently insulated with a 1-in. blanket of polyester urethane foam (supplied by William T. Burnett & Co. and applied by Armstrong Contracting and Supply Corp.). The foam has been used for similar tank insulation applications and is claimed to be competitive (because of reduction in application labor required) with magnesia blocks, calcium silicate blocks, mineral wool, and other forms of insulating materials. On a recent job quotation, the urethane "blanket" choice saved about 30% over the installed cost of mineral wool insulation and about 35% over calcium silicate block.

• • • • •

Dayton Rubber Co. has experimented with filling rubber tire tubes with controlled-density urethane foam. To test the tire, holes were drilled through the sidewall and a 3-in. wide, pie-shaped wedge was cut across the tire—yet the tire remained intact during subsequent driving. The foam-filled tire also showed greater stability and less lateral distortion during high speed cornering and better shock absorption without the reciprocal "bouncing" effect shown by air-filled tires. Dayton Rubber has also experimented with a new technique for making use of urethane in creating protective foxholes for wartime use. Using a portable mixing machine, the shoulder-depth foxholes can be sprayed with urethane foam. When hardened, the foam forms

FOAMED foxhole cover

a rigid coating that not only provides excellent insulation, but prevents water seepage. Using several strips of preformed flexible urethane foam and ordinary wrapping paper, a dome-shaped cover complete with vision slit could then be created and coated with several successive layers of rigid foam, so that the resulting foxhole cover is strong enough to support a man (see photo, p. 288). Dayton also foresees using a similar technique to construct fully insulated and waterproofed warehouses under the ground.

• • • • •

Two new applications for foamed-in-place urethane based on Allied Chemical's Nacconate isocyanate:

1) Urethane foam is being used in leading aircraft research and development centers to construct wind-tunnel test models having greater adaptability, at lower cost. Although light enough in weight to permit a wide range in experimentation, the models are tough enough to take tumbling better than the balsa wood versions previously used. At Chance Vought Aircraft, for example, the foam (supplied by Minnesota Mining and Mfg. Co. and Emerson & Cuming) is poured directly into a mold and allowed to foam around a wooden or metal skeleton. A fibrous glass-epoxy laminate, previously layed-up in the mold provides the model with a hard, smooth skin for minimum wind resistance.

2) Using urethane as the foamed-in-place insulation for an ice cream freezer lid has made it possible to cut the production steps down from 17 to four and the lid is much more attractive, stronger, more sanitary, and more completely insulated than its predecessor. The four steps (as used by Keaton Rubber Co.) include: a) mold a neoprene frame with integral hinge and knobs and a stainless steel bottom pan in each lid half; b) trim; c) foam urethane in each lid cavity (correct amounts of polyester prepolymer and isocyanate are automatically measured and dispensed by a Nopcomatic mixer supplied by Nopco Chemical Co., who also supplies the foam); and d) as soon as foaming starts, emplace stainless steel cover plates, clamp in a jig, and cure the foam in a warm room.

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A series of practical, lightweight rigid foam systems have been developed by the Plastics Div. of the Nopco Chemical Co. Available in both Freon and non-Freon formulas, the new Lockfoams can be foamed to lighter weights, have very low thermal conductivity, and high flowability. Foam weights available with these systems range from 2 lb. to as low as ½ lb./cu. ft.; K factors run from .22 for non-Freons to as low as .14 for Freon blown systems; and flowability of both systems is high enough so that a 2-in. thick panel measuring as much as 8 by 4 ft. can be filled with one pour.

Also from Nopco: Merrifield Trucking Co., Anaheim, Calif., has switched to Lockfoam urethane for insulating refrigerated trucks designed for hauling frozen foods; steel building panels fiilled with urethane foam have been manufactured by U. S. Steel Homes and successfully installed in the outside walls of a new office building; foamed urethane is being used to fill structural voids in the new atomic submarines; and a polyurethane foam float is now being used in mine-sweeping cable.

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Rigid, lightweight polyurethane foams (Marblette Corp.), provided as a two-part system, give almost instantaneous foaming-in-place: foaming can be complete in as short a time as 3 minutes. Properties include: toughness, dimensional stability, and close cellular structure. One of the new foams has a density of 6 lb./cu. ft.; the other, 2 lb./cu. foot. The latter can be exposed continuously to temperatures up to 250° F. and intermittently to 300° F. Foam blocks made with the material can be fabricated on standard equipment into the desired shape. Applications include foam cores to lighten the weight and reduce cost of plastics tools and dies, electronic and other insulation, and marine flotation.

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The development of a new type of automotive seat which combines metal springs and urethane foam in one integral unit has been announced by Reynolds Chemical Products Div. The unit combines the best features of both spring construction and design characteristics of the urethane foam. Plans are being made for plant production of the seats for use in 1960 model cars.

SEAT has foam plus springs

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By incorporating 1 to 2% phosphorus into the chemical structure of urethane foam, Viriginia Carolina Chemical Corp. claims to make the material completely self-extinguishing. Costs are not raised since the organic phosphorus compounds simply replace one of the conventional ingredients. Although both polyester and polyether flexible foams can be made with phosphorus, only the polyesters in the rigid family can be made with phosphorus.

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Seals and vibration dampeners made of urethane foam encased in vinyl tubing (Foamedge, The Sterling Alderfer Co.) are offered for various industrial uses. The product is soft and flexible and compresses to a fraction of its diameter, with full recovery when released. It is self-adhesive and adheres to most plastics, clean metal, wood, and glass.

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A new series of products (Alamask RLT 482, 483, and 28, Rhodia, Inc.) corrects odors present in many fresh urethane foams.

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A new development in the filtration field is the use of Scott Paper Co.'s urethane foam as the filter material in Philco Corp.'s line of 1959 window air conditioning units. The foam has a completely open-pore structure which gives it high porosity and 100% permeability; it has proved superior to conventional filtering materials such as fibrous glass, aluminum mesh, or aluminum weave on many counts: 1) assures longer filtering periods between cleanings, longer life of the moving parts, and greater efficiency of the cooling units; 2) can be removed easily, washed like towelling in ordinary household detergent and hot water, and then reinstalled; 3) it is not affected by high temperatures and can be sterilized, if desired, in boiling water. The material shows potential in other areas of the filtration field for such devices as air compressors, pneumatic and air moving equipment, air cleaning in internal combustion engines, and in such other items as liquid and gas detraining devices.

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A rigid, high-temperature-resistant, foam-in-place urethane (Eccofoam FPH, Emerson & Cuming) will withstand continuous exposure to 400° F. and even higher temperatures for short periods. It is used for electronic embedments, radome cores, void filling, and a variety of applications where temperature resistance is required.

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New foaming resin (Rigithane 334, Thiokol Chemical Corp.), designed for use with halogenated hydrocarbons, will provide low-density foam with good structural strength and low thermal conductivity. It will complement Rigithane 112 foaming resins now going into curtain wall sandwich panel constructions, as insulation for metal kitchen cabinet doors, as insulation for milk coolers, as buoyancy members in reinforced plastics boats, in packaging, in encapsulation, and for molded items such as pilot ejection seats for aircraft.

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Foamed unsaturated polyester (Estafoam, Vanguard Products) is an entirely new type of rigid foam which shows promise for such applications as sandwich building panels, insulation, and shock cushioning. Unlike urethane, it is poured, not foamed-in-place, thus making it easier to control density, distribution of reinforcements, etc. HET acid polyesters can be incorporated to produce fire-resistant foams.

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A flexible polyether moldable cushioning material (Pelron Corp.) is designed to completely eliminate knit line or "bones" and for ease of production without complicated pour patterns. It is produced in densities from 2 lb./cu. ft. and up.

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A new polyether (Atlas Powder Co.) derived from low-cost sorbitol and designed for rigid urethane foams has six hydroxyl groups available for cross-linking. Since rigid urethane foams can use up to 60% by weight of this new polyether, manufacturing costs can be reduced up to 25 percent.

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A special grade of dibutyl tin dilaurate (Niax Catalyst D-22, Union Carbide) is many times more active than fast amine catalysts commonly used for the manufacture of polyether urethane foams, is useful for "one-shot" foams. Another new product, a polyol polyether (Niax Triol LK-380) is used in the preparation of rigid urethane foams and offers improved aging characteristics, reduced water sensitivity, and favorable economies over polyesters.

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Bostrom Corp. has produced molded urethane inserts with vinyl covers and skins for use in instrument cases. The company has also done considerable work with semi-slab stock in which the periphery of the slab is molded and the slabs are produced by slitting a large molding. Other techniques have been developed for split molding or molding two articles back-to-back and slitting apart after molding.

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Premolded rigid urethane foam insulation designed especially for low-temperature applications down to —30° F. is being marketed by Baldwin-Hill Co., Trenton, N. J. According to the company, the material has a K factor of 0.096 at a mean temperature of 0° F.—less than one half of other industrial insulation suitable for low-temperature use.

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Inexpensive protective packaging made from chopped urethane foam which is bonded to form a uniform product is offered by Henry B. Katz Ind., Newark, N.J.

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Granulated foam is also being used as a soil conditioner and as a retainer for liquid or organic fertilizers (AgraFoam, Somerset, Mass.).

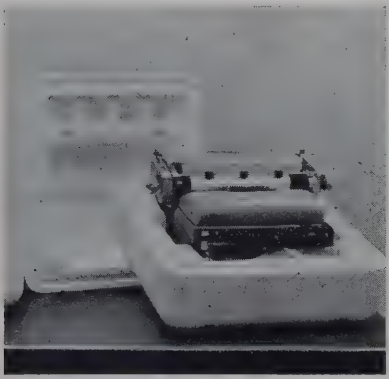
EXPANDED POLYSTYRENE

Dow continues to concentrate on adapting expanded polystyrene to a variety of specialized industrial uses. One such use is in the construction market. Originally, Styrofoam was used in building as a plaster base, for perimeters, and in filling wall cavities. Last year the company introduced Scorboard, a black expanded polystyrene board, prescored for rapid installation. This year, the company has come out with Roofmate, an expanded polystyrene board wrapped in asphalt-laminated kraft paper. Roofmate has one of the lowest heat transmission rates of any commercially available insulation. Because it is waterproof, its insulating efficiency does not deteriorate with age, as there is no moisture penetration to weaken the material's structural properties. In most cases, additional vapor barrier is not needed. Although extremely light in weight (1-in. board weighs about 3 lb. in sizes 2 ft. by 4 ft.), it has a compressive strength of 3000 lb./sq. foot. It can be applied with conventional roofing techniques and, in addition to industrial flat or low-pitch roofs, holds promise for residential use in gravel roofs.

EXPANDABLE POLYSTYRENE

A new insulated featherlight disposable cup molded of expandable polystyrene (by Crown Machine & Tool Co., using Dylite supplied by Koppers Co., Inc.) keeps hot beverages hot—and cold beverages cold—much longer than paper cups. In addition, there is no annoying condensation on the outside or bottom of the cup. Because the material is nonabsorbent and waterproof, it does not get soggy if liquid is allowed to remain in it for any length of time.

The cups are made by a new process combining vacuum, extrusion, and injection molding, in which polystyrene beads are continuously fed into a machine containing special low-cost molds.



TYPEWRITER packed in foam

In packaging, a molded foam pack (see photo, above) has been adopted as a complete shipping container by Royal McBee Corp. for its 47-lb. electric typewriter.

Another unusual application for Dylite has turned up in crash helmets lined on the inside with expandable polystyrene. The foam liner distributes and absorbs shock force and decelerates high velocity impact to a fraction of its original intensity *before* it reaches the head.

In the furniture field, frames molded of Dylite that are five times as strong as those made from wood and which result in finished pieces whose weight is only about one-third that of wood-frame-based types are now being made available to the trade.

Picnic coolers molded entirely of expandable styrene foam and molded foam supports for industrial and consumer packaging also loom on the horizon as major markets for the material.

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Expandable polystyrene beads (Pelaspan 18, Dow Chemical Co.), with self-extinguishing characteristics, are intended for applications in the general molding, air conditioning, refrigeration, appliance, and panel construction fields. No additives are required. Steam is used in the process of foaming the material in place. Dow reports it is entering such fields as molded transportable food freezers (Glo-Brite Products, Chicago), cores for home construction panels (Alcoa), and cores for aluminum panel sandwich constructions used in refrigerators (Westinghouse).

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Fire-retardant polystyrene foam (Uni-Crest, United Cork Co.) is suitable for bracing, blocking, and surface protection of packages. When molded with a polyethylene shell, it makes a lightweight "unbreakable" toy. Colored beads can be molded together to produce finished products with a mottled effect throughout. Weight range is from 1 to 20 lb./cu. foot.

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Self-extinguishing foam insulation (Lo-K, Plasti-Foam Corp.) produced from polystyrene beads by a new process, is 30% lighter in weight than other polystyrene foams and has a lower K factor than many other foam insulations. Molding is done directly from the raw material without coating the beads.

FOAMED PHENOLIC

Available from Rezolin is Corfoam 114, a three-component system consisting of a phenolic resin, a liquid accelerator, and a dry powder foaming agent. It can be foamed in large masses without the addition of heat or pressure to produce a hard honeycomb-type cellular material. (Caution: Work area must be well ventilated to avoid fumes). It can be used as a foamed-in-place material or removed from the mold when hard and readily fabricated into desired shapes with ordinary wood-working equipment. The density may be varied by changing the proportion of foaming agent to resin and accelerator.

MISCELLANEOUS

A flexible, low-density polyethylene foam has been placed on the market in limited quantities by The Dow Chemical Co. Density is about 2 lb./cu. ft. and the material has high shock-absorbing ability, is easily fabricated with conventional wood-working or power tools, has low water absorption and low moisture vapor transmission rates, high solvent and chemical resistance at room temperature, good insulation value, and no odor. It is recommended for flotation applications, thermal insulation, packaging, and fabricated industrial parts, such as gasketing.

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Colton Chemical Co. manufactures two types of foamed ureas: one is a preset foam available in block or shred form as a low-temperature insulator; the other is based on the use of tiny urea spheres as a component of syntactic foams. The latter is used in a number of plastic or rubber articles to decrease weight or to improve on various physical and mechanical properties.

rising foam. Even in intermittent mixing when filling molds continuously on a conveyor system, this manner of laying foam for each mold is suggested. Where many rigid or semirigid formulations are used, the liquid blend must be introduced through one or several holes. In such instances, it is best to slow down the formulation so that most of the charge (if possible, all) is added before a marked foam rise begins. Many foaming troubles can be avoided if this problem of laying foam on foam is taken into account in designing for foam-in-place applications.

Molding polyurethane

Inherently, the polyurethanes are adhesives and have found use as such. Hence, it is found that foaming-in-place is accompanied by a tendency to adhere in place. Thus, many foams demonstrate good bonding to metals, wood, polyester laminates, etc. To insure best adhesion, the surfaces against which the foaming takes place should be freed from grease by a solvent wash and preferably mildly roughened. In some cases, improved bonding may be obtained by priming with adhesives. With vinyl film, for example, adhesives are required.

Loss of heat from the interface during foaming results in reduced bond strength. This may be remedied by a preheat and/or a postcure. In most commercial applications, the only function of the postcure is to complete the reactions at the surfaces which were retarded by the loss in heat. The cores of most foams are self-curing due to the retention of the heats of reaction by the excellent insulation properties of the foam.

It is possible to form molded objects of polyurethane foam *in situ,* characterized by good, smooth, tough skins and with excellent reproduction of the mold details. Rigid, semirigid, or flexible varieties can be used. In these cases, it is necessary to have mold frames coated with good mold releases, e.g., polyethylene, Teflon, silicone resins (silicone oils tend to be wiped clean by the rising foam and the foam then adheres to the uncovered areas), waxes, etc.

The design of the mold frames must take into account many factors. As gas pressures are developed during the foaming processes and subsequent curing, provision must be made in the design for reinforcement jigs that can withstand these pressures. The amount of reinforcement required for any given formulation and application is difficult to predict. Experience in handling is the best guide. Prepolymers (total) usually require less reinforcement than quasi systems which, in turn, require less than one-shot systems. The restraint pattern and total excess of components used are two other important factors.

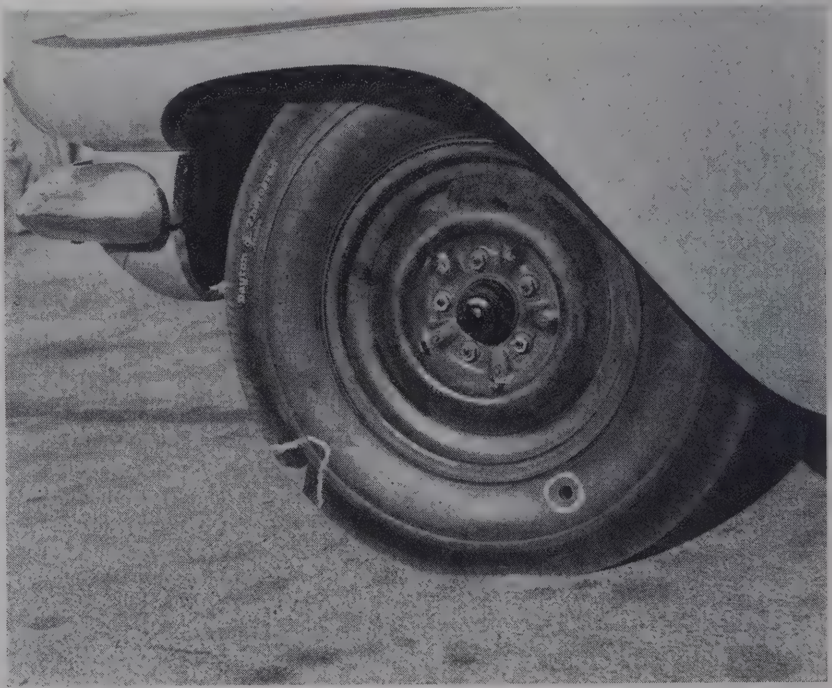
Openings for the introduction of the blended liquids is a most important consideration in mold design. If possible, provision should be made for an opening large enough for a lay-down pattern on the bottom to avoid laying liquid upon rising roam. If this cannot be done, as many large pour holes as possible should be incorporated in the design of the mold forms. It is necessary to provide for air vents to prevent formation of air pockets, which would be centers of structural weakness.

In the case of molded objects, still other design factors must be taken into consideration. As the usual foams in commercial use show very little tendency toward shrinkage drafts must be built into the mold forms so that the molded foam may be removed without too much trouble and with a minimum of damage. This factor is not as critical for flexible foams because of their deformability.

To obtain smooth skins and good release, it is essential that the walls against which the foam is being produced shall be as smooth as possible. Of course, the application of mold releases with proper buffing will tend to produce the required smooth surfaces.

Spray-on foam

One of the more recent developments in the field of industrial applications of polyurethanes is the production of foam upon a surface (horizontal or vertical) by dispensing the foam ingredients from specially constructed spray guns. The two component streams are simultaneously atomized and mixed externally by an impinging air blast immediately outside the tip of the spray gun. In this manner, it has been found possible to form fairly even coats up to 1 in. thick upon walls, ceilings, or floors. Thicker coats may be obtained by several passes of the gun. Foam formulations have been devised so that the foaming action starts almost immediately,



CLOSE-UP OF URETHANE FOAM-FILLED TIRE which, in spite of mutilation, continued to provide normal support and stability during road tests. (Photo, Dayton Rubber Co.)

even before the mass strikes the surface, and may be completed in 5 to 6 seconds. Additional coats may be applied less than 20 sec. after the last coat has been put on the surface.

The first spray-gun applicators developed could handle total prepolymer systems. This meant that they were capable of handling foam ratios in which the catalyst portion represented only a small portion of prepolymer by weight. Later, spray guns were developed which could handle quasi-prepolymer systems (or ones where the two components were close to each other in magnitude). In order to obtain good flow characteristics, recourse to heating the components is necessary in many cases. Therefore, heated reservoirs and heated circulating lines used in conjunction with metering mechanisms are required in addition to the spraying equipment. Since mixing is external to the gun, the cleaning problem is minimized. It should be kept in mind that in this operation the ventilation problem is made more acute. Provision must be made for adequate forced air ventilation, especially if interior work is being contemplated. The operators should be protected further by wearing free air masks and protective clothing.

Structural applications

One of the earliest applications of urethane foams, based on their excellent strength/density ratios, was in structural reinforcement. In the aircraft industry, for example, where weight considerations are of the utmost importance, foam was employed to fill cavities even when the material costs were still high. These foams are truly elastic and can withstand vibration; because they can be poured-in-place and adhered-in-place, labor costs can be cut tremendously. Foam is used in ailerons, wing tips, control sections, cowlings, gas tanks, propeller cuffs, door panels, etc. As the price of isocyanate formulations dropped, more cavity filling applications became feasible. A most interesting one is the use of foam in filling nonfunctioning cavities and structural voids in submarines. Replacement of the conventional resinous pitch and white pine reduced the weight of fill about 8½ tons per atomic submarine—and added strength. The reduction in labor and time was highly significant.

In sandwich constructions, the technique involves foaming-in-place between thin aluminum and plywood skins. Shelter huts represented the first step along these lines. The field of house and office construction represents the largest potential for rigid and semirigid foams, with prefabricated walls, roof panels, etc., expected to be among the earliest applications. Also strong, light-weight structures using plastics skins (such as polyester laminates) with foam cores have a large potential. The possibilities have been demonstrated by trailer bathtubs, sailboats, canoes, floats, etc. In the latter cases, the foam also contributes to buoyancy. Other applications are represented by rifle butts and stocks.

In many of the above applications, both rigid and semi-rigid foams can be used. The main criterion is the expected temperature of application and load-bearing strengths at these temperatures. Many semi-rigid foams have excellent strengths at room temperature.

Thermal applications

An even greater potential than structural applications is in insulation applications, although the two fields may often overlap. Water-blown rigid and semirigid foams have thermal conductivity factors that are as low as, if not lower than, any other insulation material on the market. They have been used extensively in railroad refrigerator cars ("reefers"), refrigerator trucks, insulated bottles and jugs, freezers, etc. Pipe insulation, especially foamed-in-place at irregular shaped joints, has been a good application. A flexible type, preformed, has been developed for snap-in-place installation. The ability to spray various foams on surfaces, both vertical and horizontal, permits these materials to be used to insulate many pieces of industrial equipment.

With the advent of fluorocarbon-blown foams, enhanced insulation properties have been obtained. With properly formulated rigid foams, the volatile solvent is imprisoned in the foam cells. The presence of fluorocarbon gas results in K factor that is lower by a factor of roughly 2. Care in formulation must be taken to insure retention of the gas. Household refrigerators will be the biggest application for this type of foam.

Flexible foam also has a place in insulation. In clothing, these cellular plastics contribute warmth with light weight. Uses such as inner liners in windbreakers, topcoats, sleeping bags, gloves, and blankets have been successful. The relatively high tensile and tear strengths permit sewing the foam into place. Industrially, flexible foam slabs have been used successfully for insulation of storage tanks.

Electrical applications

Perhaps the first large use of polyurethane in this country was in the fabrication of radomes. Transmission of radio waves (in particular radar) and low tangent losses are excellent. Airplane radomes made of polyester laminate with rigid foam cores have been used extensively. At present, large scale radomes without skins but with coatings for radar-stations are a reality.

Electrical potting is also a big application for rigid foam. The dielectrical strength is good and the components are kept firmly fixed in place, protected from vibration, dampness, corrosion, and from attack by fungi.

Energy absorbing applications

The versatility of foam formulations permits varying of the so-called "deadness" of flexible foams. Foamed-in-place formulations are used in automobile crash pads and safety visors. Comfort devices such as ear pads represents another use.

The ability to absorb energy or shock absorption is also put to good use in packaging. Here, contour foamed-in-place packages, as well as slitted slab stock, can be used. In addition to flexible foams, there are uses for semi-rigid foam in this field. Shipping cartons packed with this material have proven successful. The principle of energy absorbing by shock collapsing of semi-rigid foam to protect delicate instruments has been found to work well.

Cushioning and other fields

Flexible foam formulations can be made with improved resiliency. These livelier foams are finding uses in various types of furniture upholstery and bedding as represented by seating, cushioning, mattresses, etc., in both slab-stock and molded forms. It is felt that their stress-strain curves are ideal for comfort. The lack of fight-back coupled with optimum plateau is believed to be responsible.

Much of the crispier flexible polyester-based polyurethane foam is used in the toy and novelty trade. The material is easily die-cut into various configurations from slab stock which has been slit in many thicknesses. Because of its resistance to abrasion, this foam has found large use in sponges for cleaning purposes.

Open cell semirigid and flexible foams show good sound-deadening effects. They can be sprayed on walls and ceilings or slit slab-stock can be employed.

An interesting application that has been abused in the past is in rug underlays. Flexible foam under rugs gives a feel of luxury and also prevents rug skidding. However, it is necessary to make sure that a formulation is used which will result in a foam that will stand up in use.

FOAMED VINYLS

By Henry E. Allen*

The most widely produced vinyl foam today is the *open-cell, flexible foam* made from PVC resins or copolymers. It resembles latex foam rubber and open-cell, flexible polyurethane, but also possesses important characteristics which differ from each of them, e.g., vinyl foam is a thermoplastic while the other flexible foams are thermosetting. *Closed-cell, flexible foam* resembles closed cellular rubber foams although it offers added advantages in the aging, chemical resistance, and fire resistance properties of all vinyl materials. *Closed-cell, rigid vinyl foam* is analogous to foamed styrene, cellular cellulose acetate, and rigid polyurethane foams. The rigid foams, which are being used for flotation purposes, such as buoys, throw rings, floats, etc., have little in common with the flexible vinyl foams now being widely used for cushioning and padding.

The flexible, open-cell foams are usually produced by incorporating an inert gas with the liquid plastisol under pressure, releasing the mixture to the atmosphere, and curing the resultant foam. Closed-cell foams, both rigid and flexible, are normally made by incorporating a blowing agent which decomposes at fusion temperature, releasing gases (usually nitrogen) during the gelling and fusing period. Each of these types of vinyl foam formulations will be discussed below.

Open-cell foam

Open-cell, flexible foams are most commonly produced by a mechanical process whereby an inert gas, usually carbon dioxide is mixed directly with the plastisol under pressure. In this process, which produces foam in commercial quantities,[1] specially prepared plastisols are metered into a continuous mixing unit and are agitated under pressure. The amount of gas absorbed can be varied by regulating the temperature and pressure at which this mixing takes place. When the mixture is allowed to escape through the nozzle at atmospheric pressure, it foams and the reaction is very similar to instant shaving lather from an aerosol can.

Vinyl foam may be produced by this method as either molded or slab stock. In producing the molded stock, the plastisol-gas mixture is injected directly into the mold as foam. The mold is then heated to fusion temperatures (approximately 360° F.) in a conventional circulating hot-air oven. When fusion of the mixture is complete, the mold is air cooled, opened, and the finished piece is stripped out. Density of products so made range from 3 to 5 lb. per cu. ft.

Slab stock is produced by discharging the plastisol-gas mixture onto a moving belt which carries the foam through the high-frequency fusion oven and then through a conventionally heated postfusion oven. This last step compensates for exterior heat losses during high frequency radiation. After cooling, the foam can be cut into standard lengths for shipment. If sheet stock is desired, the slab may be sliced horizontally into thicknesses of 1/16 to 4 in. and wound on rollers. Sheet stock is manufactured up to 56 in. wide and as long as 35 feet.

Properties: During the manufacture of open-cell vinyl foam many modifications in the foam can be made by changing the plasticizer-to-resin ratio, or controlling the temperature at which the gas and the plastisol are mixed. The latter will modify the foam density while the addition or reduction of plasticizer increases or reduces the resiliency of the foam at a given density.

To meet the requirements of one of the largest markets—furniture cushioning and padding—vinyl foam offers comfort and durability. Cushions molded from open-cell vinyl foam have proved to be soft and resilient without bounciness and have been widely accepted by the furniture industry. The retention of original dimensions and maintenance of load carrying ability are of prime importance in all types of seating applications. Vinyl foam takes minimum permanent set, and tests have proved that flexible, open-cell vinyl foam is remarkably resistant to shrinkage and loss of compression.

Properly fused, the foam exhibits outstanding aging and stress characteristics. It does not oxidize, dry out, or harden and is not subject to hydrolysis during long periods of high humidity and heat.

Of course, the foam also has vinyl's inherent resistance to most inorganic acids, alkalies, oils, greases, aliphatic hydrocarbons and alcohols. Fabricated in white or in color, it has shown no tendency to fade or darken during use.

Fabricating open-cell foam

Because vinyl foam is a thermoplastic, it lends itself to many uncomplicated fabricating procedures including electronic heat sealing, embossing, printing, and wire cutting techniques. It is easily bonded and will laminate to films, fabrics, and cloth by the application of heat.

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*Mgr., Vinyl Foam Div., Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 East 42 St., New York 17, N. Y.

[1] Elastomer Process; U. S. Patent 2,666,036.

Electronic heat sealing: Sheets of open-cell vinyl foam are readily and inexpensively fabricated into finished products with electronic heat sealing equipment. The only fixed investment is a heat sealing press and an air compressor. The dies for this machine are inexpensive, ranging as low as $50, and standard heat sealing units can be used to form such varied end products as sponges, brushes, sun visors, arm rests, etc. Tear-seal dies may also be used to eliminate expensive die-cutting and trimming steps.

Slab or sheet trimming: Design requirements for furniture and transportation seating often prevent the use of thick molded cushions. Instead, slabs or sheets of vinyl foam can easily be adapted to these applications, since they can be trimmed to size with conventional slicing or splitting operations. The fire resistance of vinyl foam plus its comfort has opened the door for many such applications.

Core- and contour-molding: Since the largest potential market for flexible vinyl foam is in cushions and cushioning products, new techniques have been developed to meet its specialized needs. During the manufacture of a cored and contoured cushion the wet foam is injected into lightweight aluminum molds where it readily conforms to the mold's inner surface. Hollow pins projecting inward from the mold cover plate form the core holes which help control the weight-resilience relationship of the finished piece.

After fusion and cooling, the cushion strips readily from the mold. By using two symmetrical cushions and bonding them together a fully cored, contoured, reversible sofa or chair cushion can be produced.

Integral skin (textured surface) molding: A thin, textured integral skin can be given to cored and contoured cushions by spraying, brushing, or slushing an unexpanded plastisol onto the preheated mold face. The mold is then closed and filled in the normal manner. When this cushion is cured, the unexpanded plastisol will form a skin on the surface that is actually part of the cushion. Thus, the entire hand upholstery operation in the manufacture of cushioning products can be eliminated. Both school and transportation seating are currently being fabricated by this method.

Electronic heat sealed laminates: Sheet vinyl foam in combination with fabrics, vinyl films, and other upholstery materials may be incorporated into a sandwich-structure laminated product which can be used for padding and quilting applications. This structure has been widely used in the furniture and automotive upholstery field.

Applications for open-cell foam

Within the past year, molded vinyl foam cushions have been incorporated into several popularly-priced furniture lines. The inherent light weight, ease of cleaning, and durability of these contoured, cored, fully reversible, vinyl cushions have allowed them to successfully replace many older, more conventional materials in the large-volume furniture market for flexible foams.

Because the flexibility and resilience of vinyl foam can be controlled quite easily during the manufacturing process, cushions of identical appearance can have markedly different cushion characteristics. This provides a measure of versatility for the cushion manufacturer.

Vinyl foam takes minimum permanent set and does not shrink; therefore, it is ideally suited for use with well-designed upholstery material. Of course, the biggest advantage to a furniture manufacturer is the lower cost of vinyl foam for cushioning and padding.

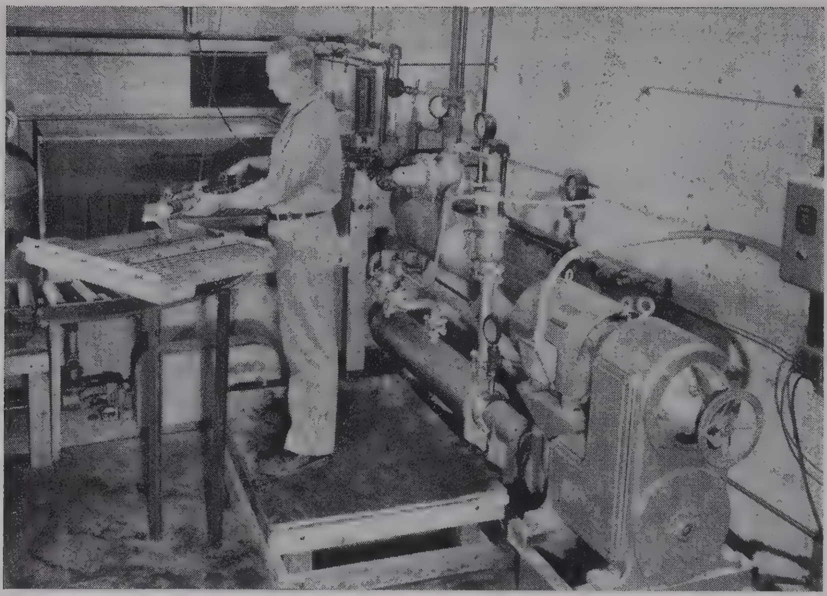
The use of vinyl foam sheets has also proved very applicable for specialty items such as lint brushes, sun visors for automobiles, cushioned foot pads, and similar end products.

Closed-cell foam

In discussions of closed-cell vinyl foam, it is convenient to classify the foams according to density. Applications requiring relatively low density (3 to 10 lb./cu. ft.) are commonly manufactured by a process called pressure-blowing or closed-mold blowing. The most important blowing agents used in the rigid or semirigid vinyl foam processes are nitrogen producing compounds, and generally, this gas is released by a chemical decomposition caused by heat. Thousands of tiny bubbles are formed within the plastisol and the foam is thus produced.

Closed-mold blowing: This technique utilizes a sealed mold in

FUSED MOLDED VINYL FOAM CUSHION does not adhere to metal mold; it can be stripped out automatically or by hand. Next, two cushions are bonded together to form tee unit. (Photo, Union Carbide)



FILLING A TEE-CUSHION MOLD with vinyl foam is a one-man job. Upon being released into atmosphere, foam expands an amount predetermined during mixing operation. Lightweight metal mold is not subjected to high pressures. Flat plate contains core pins. (Union Carbide)

which relatively thick sections of closed-cell vinyl foam are produced. The expansion may be completed outside the mold, but the foam usually retains the details and proportion of the mold.

Of course, caution must be exercised because of the pressure build-up within the mold. An improperly stabilized vinyl system may break down, and this added pressure must be taken into consideration during the calculation of a safety factor. A typical molding cycle starts with the mold, filled with the unexpanded plastisol paste, clamped in a steam heated press. The cycle may range from 15 to 25 min. at 320 to 350° F. Following this fusion period, the closed-mold is cooled. The center of the plastic mass should be well below 200° F. before the mold is opened; otherwise, rupture of the soft stock may occur.

The piece at this point is partially expanded, and it is brought to its maximum expanded size by heating for approximately one hour at temperatures of about 220° F. Additional annealing may be advantageous and is usually accomplished by maintaining the piece at temperatures of from 130 to 150° F. for several hours.

Foam sections produced by this closed-mold technique are necessarily limited in size. The foam can, however, be sliced to whatever thickness is required.

Where large sections of rigid foam are required, the user will probably look to atmospherically blown foam although products from this technique usually have medium to high density (10 to 45 lb./cu.ft.).

Foam thus produced usually contains a large percentage of interconnecting cells although manufacture of closed-cell foams is sometimes possible. Because of this, if finished products require optimum flotation or insulation properties, closed-mold techniques instead of atmospheric blow are used.

The atmospheric method involves casting plastisol into an open mold or coating a web with vinyl dispersions into which a blowing agent has been mixed. The material is then fused at temperatures of 330 to 400° F. and allowed to expand at atmospheric pressure. The blowing agent-plastisol ratio in this process is generally much lower than in the closed-mold method.

Two systems are commonly used for producing atmospherically blown closed-cell vinyl foams and are called post-fusion and pre-fusion expansion techniques. The first utilizes a blowing agent which decomposes at the fusing temperature while the latter involves less stable agents that will decompose completely at temperatures near 175° F. and slowly produce gas even at room temperatures. This process can be marketed as a two-package product; the buyer mixes the ingredients just prior to use.

Post-fusion allows the plastisols to be applied by spraying, knife or roller coating, hot or cold dipping, slush molding, and casting. The post-fusion process thus permits gaskets to be foamed *in situ* for refrigerator doors and drum liners. The excellent sealing and weather resistance available from these closed-cell foams have made them popular as weather stripping.

The *pre-fusion* technique produces closed cell vinyl foams with excellent cell structure—the densities range up from 10 lb./cu. ft.

Properties of closed-cell foam

Foams produced by both the pressure-blow and atmospheric-blow methods can be varied from rigid to flexible by the adjustment of the plasticizer content. Some rigid closed-cell vinyl foams have excellent shock-tear-abrasion resistance and are also relatively unaffected by the action of most oils, salt water and acids. These closed-cell foams have a K factor of about 0.27 and should find use as insulation materials.

Applications for closed-cell foam

Semirigid closed-cell foams have already been used widely for marine application such as boat fenders, life buoys, fish net floats, and kick boards. This material has also been used as insulation and should find increased use in the future in such applications as refrigerator rooms, trucks, and railway cars.

Flexible closed-cell foams are also noted for their buoyancy and insulating values. They have been used in protective wear, i.e. helmets, shoulder pads, and knee pads. Perhaps a more spectacular use is their incorporation in survival suits. They not only provide warmth, but buoyancy, when worn in water. Sheets of this flexible foam have also been adapted for use as innersoles for shoes and slipper soles.

Other applications which are being developed for molded items include grommets and earphone pieces.

EXPANDABLE POLYSTYRENE

By W. J. Gort*

Expandable polystyrene is produced as free-flowing beads containing an integral expanding agent. When exposed to heat, these beads will expand to over 60 times their original volume—to as low as 1 lb./cu. foot.

Properties

Unique properties of the foam are: closed-cell structure, controllable density, low thermal conductivity (K factor), low water absorption, low water vapor permeability, toughness, excellent dielectric characteristics, and all-around adaptability. It is dimensionally stable at ambient temperatures up to 175° F.; it resists acids, alkalies, and the lower alcohols, but is susceptible to attack by polystyrene solvents such as ketones, esters, and aromatic hydrocarbons.

The foam does not embrittle at low temperatures. Unnotched impact tests on specimens at a density of 2 lb./cu. ft. stored at –100° F. for 48 hr. indicated no loss in impact resistance.

The K factor (coefficient of thermal conductivity) of the foam is 0.242 at 2 lb./cu. foot (A.S.T.M. test method C-177-45). The K factor varies somewhat with density with a minimum value between 1 and 2 lb./cu. foot.

The water absorption of the foam is extremely low because of the noninterconnecting cell structure. The water absorption, after 48 hr. immersion under hydrostatic pressure equivalent to 10 ft. of water, is less than 0.9% by volume.

The very low water vapor transmission rate is 1.0 to 1.7 grains/hr./sq. ft./in. of thickness/in. Hg vapor pressure difference (by A.S.T.M. Method C355-54T).

Applications

Self-extinguishing grades of expandable polystyrene meeting the requirements of A.S.T.M. test No. D-635-44 are now commercially available.

One of expandable polystyrene's early — and still-growing — uses was in the manufacture of toys, novelties, and displays. Silk-screened, dry-colored, and artfully beribboned articles in this category have found popular success.

Expandable polystyrene has also found a ready market in low-cost, low-temperature insulation, e.g. low-temperature pipe insulation. Board insulation is finding enthusiastic acceptance for the construction of coolers and freezers. Refrigerator drip trays, freezer evaporators, evaporator supports, and liner shields of expanded polystyrene are being extensively used in the refrigeration industry.

Low-density expanded polystyrene has also proven applicable for consumer, industrial, and military packaging. Its strength, water resistance, and insulating qualities, for example, have led to its use for shipping containers for whole blood, plasma, and perishable drugs. Delicate instruments and intricate parts are cushioned effectively by dunnage molded from the beads.

Foamed polystyrene core boxboard has recently appeared on the market, offering greatly increased wet strength, excellent insulation, and enhanced cushioning over conventional materials.

Sandwich constructions in which the expandable polystyrene is foamed at controlled densities between sheets of plastic, plywood and aluminum show promise in the construction field.

Expandable polystyrene also has exceptional buoyancy characteristics and "in-place" moldings are already being used in boats, buoys, etc., to replace air tanks. Puncturing such molded pieces will not affect their buoyancy characteristics.

Techniques

Foaming expandable polystyrene beads ordinarily comprises two discrete steps:

1) Unconfined heat pre-expansion of the virgin beads (the translucent beads assume a spherical shape and become white in color); and 2) further heat expansion of the pre-expanded beads within the shaping confines of a mold to produce a smooth-skinned, closed-cell foam of controlled density, registering every detail of the mold.

Extrusion and virgin bead molding are the chief exceptions to this two-step operation.

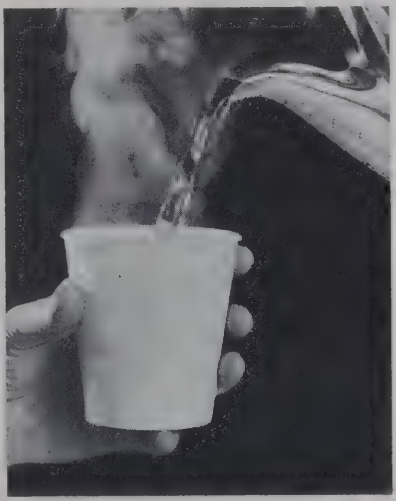
○ Panels with expandable polystyrene cores have recently been introduced in the home building field. Some structural panel components have received FHA acceptance. The whole structural framework of the NAHB 1958 Research House utilized these panels which came in various sizes up to 4-ft. wide and 18-ft. long, with a 3½ in. foam core in the thickest panels, which were employed for the roof.

A new technique in extremely high-volume, thin-wall molding has made possible an insulating foam plastic cup which is competitive with paper cups for hot and cold liquids.

In furniture molding, the use of expandable styrene has simplified free-form design. The foam plastic takes the place of the normal, and complicated, shaped wood frame, and results in a stronger, lighter, and more durable piece of furniture.

Pre-expansion techniques: Batch pre-expansion is suitable for preparing small quantities of the beads for experimental purposes, if close control of the pre-expanded density is not critical. In such instances a common infra-red heat bulb is mounted 4 to 5 inches above

INSULATED, LIGHTWEIGHT disposable cup is molded of expandable styrene, can hold boiling liquids without discomfort to hand. (Koppers)



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*Technical director, Expandable Polystyrene Development Dept., Plastics Div., Koppers Co., Inc., Monaca, Pa.

NOVELTY CHRISTMAS ITEMS molded of expandable styrene have virtually taken the market over from paper. (Photo, United Cork Co.)

a tray and the beads are distributed in a thin layer over the bottom of the tray and allowed to expand.

In all the other techniques described below, the beads are pre-expanded to the approximate required density to ensure uniform expansion in the finished product.

The most successful and adaptable method of pre-expansion utilizes continuous expansion by means of steam.[1] In this process, the unexpanded beads are fed continuously by aspirating with steam into a drum. Revolving agitators prevent fusion within the drum. Pre-expanded beads emerge continuously from the top of the pre-expander and are conveyed by air to suitable storage bins. This method permits controlled production of densities between 1 lb./cu. ft. and 20 lb./cu. ft. at high rates.

Pre-expansion can also be accomplished by moving belt under infra-red strip heaters or by immersion in hot water.

Molding: There are several different molding techniques. The selection of the proper method depends on a variety of factors, including the size, configuration, density or maximum thickness of the finished part, and the volume of production. The various molding techniques for expandable polystyrene are discussed below. They include molding by steam chest, autoclave, or steam probe. Each, of course, has its own particular advantages, as well as limitations, and the potential end-user should investigate each thoroughly before making a final choice as to which one would more nearly fit his own production requirements or the requirements of the end-product.

Steam chest—In this method, steam is introduced directly into the mold cavity through holes drilled through the mold from the steam chest into the mold cavity, or by other means, such as core box vents. Single- and multiple-cavity molds with steam chests are suitable in hydraulic or air cylinder clamping presses. They may also be used without presses, if a suitable clamping method is provided on the mold.

Autoclave—Certain articles are successfully formed by exposing a filled, perforated mold to steam within an autoclave. This method allows for cooling outside of the autoclave and therefore permits high production rates, but with a higher mold cost.

Steam probe—For most foaming-in-place applications, sandwich construction, or various large area, thick-section applications, steam probes are used for steam introduction into mold cavities. Aluminum, brass, or copper tubes are sealed at one end and perforated. The other end is attached to a flexible hose or a multiple probe header. The cavity, or mold, is filled with pre-expanded beads of the required density, probes are withdrawn immediately and expansion of the expandable polystyrene fills the space previously occupied by the probe. Air, water spray, or water immersion cooling may be used.

Conduction heating: This method involves the use of molds which do not provide for direct introduction of steam into the cavity from the steam chest. This method is suitable for uniform thin-wall moldings, but is not recommended for wall thickness greater than 1/4 inch.

Radio frequency molding—New techniques have been developed for molding expandable polystyrene by using radio frequency as the source of heat.[1] This technique, utilizing inexpensive plastic molds, is recommended for small-volume runs which would not justify the cost of metal molds and, in certain cases, where conventional steam or probe methods are not practical.

Extrusion: Tubing, film, and sheet of varying densities can be produced using conventional blown film extrusion equipment. The extruder is equipped with specially designed dies and blown-film take-off equipment which are intended to control expansion, width, and densities of the end product.

The extruded product is non-friable, the surface presenting a smooth, even appearance with the absence of individual bead formation. Conventional extruders with low compression screws and high L/D can be used with special formulations.[1]

The extruded sheet may be formed continuously as it comes from the extruder, before it cools completely, by vacuum forming or by compression molding. The expandable polystyrene sheet may also be vacuum formed in conventional equipment into a variety of shapes. For best results, the depth of the draw should not exceed the width of the opening.

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[1] Patent has been applied for by Koppers Co., Inc.

EXPANDED POLYSTYRENE

By R. W. Theobald*

Produced by expanding polystyrene up to 40 times in volume, expanded polystyrene is supplied in the form of blocks, sheets, etc. Thus, the end user need concern himself only with its fabrication or installation and the selection of the correct density to meet his needs. Among the forms thus far available are: standard white Styrofoam 22; a blue-colored self-extinguishing type known as Styrofoam 33; a medium-density foam which weighs about 3 lb./cu. ft.; and a 4½ lb./cu. ft. foam known as Styrofoam HD-2.

Properties and uses

Among the attributes that make polystyrene foam useful for thermal insulation in building construction is a compressive strength high enough to permit the placing of concrete or metal floors directly over the material without additional support. The unicellularity of the foam prevents the absorption of water or water vapor and insures against any decrease in insulating efficiency. This is of great importance where freezing temperatures are encountered.

The low thermal conductivity, good structural strength, and rough surface texture of polystyrene foam facilitates its use as a combination insulation and plaster base in residential masonry construction. Direct plastering over the foam is entirely practical; the surface requires no preparation to receive the plaster.

The high shear-strength of polystyrene foam makes it an excellent core material for sandwich panel construction, especially where a lightweight insulating panel is required.

Packages and display platforms fabricated from polystyrene foam offer both a pleasing appearance and a measure of protection for the contents. The foam will absorb considerable shock on impact and can be used to protect fragile articles in shipping and warehouse handling.

Polystyrene foam is used extensively in the field of buoyancy because of its light weight and closed-cell structure. With a buoyancy factor of 55 lb./cu. ft., it is used by boat manufacturers to replace airtight compartments and by manufacturers of life rafts, swimming rafts, aquaplanes, navigation buoys, and floating docks.

The floral field finds the foam useful because of its light weight, attractiveness, colorability, and the fact that its cellular structure holds the stems of flowers firmly in place. The display and novelty field uses the foam for holiday decorations, window and counter displays, carvings, and signs.

Fabricating the foam

The foam can be cut with conventional hand or power woodworking tools. As examples, symmetrical objects may be fabricated by feeding a flat blade having the desired contour into a rotating piece of foam, or a piece may be hollowed out with a flat blade router. Nonsymmetrical pieces are either carved by hand or on a multiple woodcarving machine. In any type of mechanical cutting, it is generally most satisfactory to operate the moving part at high speed using a slow feed.

Plain and curved surfaces may be cut with an electrically-heated wire. In using this method, a piece of the foam is fed into a shaped Nichrome wire or ribbon that is held at a temperature just below red heat.

Thin sections of the foam can be successfully die cut. Either a heated melting-type cutter or a shear-type cutter may be used, depending on the piece being fabricated.

Fabricating areas should be equipped with adequate ventilation systems to remove the blowing agent, methyl chloride, released on cutting through the cells.

Bonding the foam

Polystyrene foam may be successfully bonded to itself and to most other materials, including masonry, wood, cloth, paper, glass, and metal. There are many factors to be taken into account, however, when selecting the proper adhesive.

Drying-type (setting by evaporation of a liquid) adhesives containing active solvents, which attack styrene, such as aromatic and chlorinated hydrocarbons, ketones, and esters, are generally not satisfactory for use with polystyrene foam.

Adhesives containing nonsolvents for polystyrene, such as water and the lower alcohols, are satisfactory in applications where the solvent can evaporate. This group includes the many water-dispersed emulsion and latex types of adhesives. They are generally suited only for bonding the foam to vapor-porous materials, e.g., wood, masonry, paper, and cloth.

FOAMED POLYSTYRENE ROOF INSULATING material is adhered to asphalt under-coating. Built-up roof of felt and hot bitumen is then applied directly over the foam. (Dow)

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[*] Plastics Technical Service, The Dow Chemical Co., Midland, Mich.

However, they can be used on non-porous materials if sufficient time is allowed to permit the adhesive to dry partially before the bonding surfaces are joined, or where spot or serrated application gives sufficient bond strength.

Adhesives containing naphtha as a solvent can often be used if caution is observed. These adhesives should be applied to material to which the foam is to be bonded and most of the solvent allowed to evaporate before the foam is finally put in place.

Cold-setting types of adhesives that harden and set by a chemical process are generally well-suited for bonding polystyrene foam. It is important, however, to test whether the adhesive will bond to the material to which the foam is to be adhered. The adhesives in this group include water-reactive materials (portland cement, plaster of paris, etc.), and the types that set by polymerization and/or oxidation (epoxies, phenolics, resorcinols, ureas, etc.)

Polyester resins containing styrene monomer are not satisfactory unless the foam is protected against the solvent action of the monomer.

Hot-melt adhesives, usually asphalt or wax-based materials, may be used if they have a workable fluidity at temperatures below 300° F. The foam distorts when subjected to prolonged exposure at 175° F. It can, however, be immersed in a molten adhesive for a short time, long enough to obtain a coat of adhesive. The maximum temperature is 300° F.

Many types of surfacing materials can be applied and adhered to polystyrene foam because of its tough surface. Plaster, pulp plaster (for lighter weight), and rubber- and asphalt-based water-dispersed weather coatings can be applied directly on the foam. Epoxy resins are also excellent surface coatings for the foam and can even be reinforced with glass fibers for added strength.

The foam can be painted to practically any desired color. Care should be taken, however, to see that the solvent used in the paint is not one that will attack polystyrene foam. In general, paints used should be based on film formers that are dispersible or soluble in aliphatic hydrocarbons, alcohol, or water.

Spraying is the most satisfactory technique for coating the foam but brushing is often used with good results.

Water-based paints are most successful for applying a colored surface to the foam, although the resulting surface is not glossy and two or three coats are sometimes necessary to cover all the surface cells.

Coatings of varying hardness and flexibility may be formulated from alcohol-soluble, film-forming materials, such as ethyl cellulose, shellac, and polyvinyl acetate. These coatings provide a tough protective surface and also may be pigmented or dyed to give glossy colored surfaces.

The foam can also be colored by using water- or alcohol-soluble dyes.

CELLULAR POLYETHYLENE

By J. A. Snyder*

Cellular polyethylene, a natural polyethylene mixed with a blowing agent that yields an inert gas when processed, can be formulated to afford expansion twice its volume.

The foamed product retains many of the inherent properties of polyethylene—chemical, moisture, and abrasion resistance, plus flexibility and toughness. There are, however, some important differences between the characteristics of solid and cellular polyethylene that have helped determine the end-uses into which the foamed material has been going. (Table I, p. 301, gives some typical values for the physical and electrical properties of cellular *versus* solid polyethylene.)

Because of its electrical characteristics, for example, the largest application for cellular polyethylene today is as primary insulation for communications cable—coaxial cables, TV lead-in wire, and other high frequency cables—where electrical attenuation and line losses must be reduced. When used for such insulation, the lower dielectric constant of cellular polyethylene (*versus* solid polyethylene) permits the space between the inner and outer conductors to be reduced without changing the character impedance. Consequently, the attenuation may be reduced by increasing the size of the inner core without increasing the over-all diameter, or the weight may be reduced by decreasing the over-all diameter without decreasing the size of the inner conductor.

Cellular polyethylene is only slightly less resistant to moisture permeation than solid polyethylene of equal thickness. Because of a balancing of external and internal vapor pressures, the unconnected cells in the material do not become filled with moisture and therefore relatively little water is absorbed. (Water absorption is plotted against water immersion time for solid and cellular polyethylene insulations of similar thickness in Fig. 1, p. 301.) In addition, no significant change in the dielectric constant of cellular polyethylene has been observed when the moisture constant is plotted against the water immersion time.

This unique combination of moisture resistance, good insulating qualities, and 50% weight reduction has made possible floating geophysical cable in which the lines are coated with cellular polyethylene. This floating cable permits the use of more complicated communication systems and greater power consumption at points miles from shore, without the need for handling cumbersome equipment.

While cellular polyethylene has been tested as a thermal insulator, its relatively low melting point restricts the use of the material to applications where temperatures remain under 90° C. The excellent chemical properties of cellular polyethylene, however, indicate its possible use as an insulator for chemical laboratory refrigerators and cold boxes.

Cellular polyethylene, in the form of extruded rod, disks sliced from rods, and disks stamped from sheeting, has also been used in such diverse applications as lightweight spacers, bumpers on small boats, and bottle caps.

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*Development Dept., Union Carbide Plastics Co., Div. of Union Carbide Corp., Bound Brook, N. J.

TABLE I: Typical properties of cellular polyethylene insulation

Property	*Solid polyethylene*	*Cellular polyethylene*
Tensile strength[1], p.s.i at 23°C.	2180	670
Elongation[1], %	600	310
Dielectric strength. A.S.T.M. D-149-55T		
Short time at 0.125-in. thickness, v./mil	550	220
Step by step at 0.125-in. thickness, v./mil	500	190
Specific gravity, 23/23°C.	0.92	0.42
Mandrel bend[2] at —55°C. & 2X	O.K.	O.K.
Dissipation factor at 1 kc.	0.00020	0.00030
10 kc.	0.00020	0.00035
50 kc.	0.00020	0.00035
Dielectric constant at 1 kc.	2.28	1.48
10 kc.	2.28	1.49
50 kc.	2.28	1.50
Compression loading[3], p.s.i.	1550	450

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[1] 32-mil specimen stripped from No. 14 AWG wire.
[2] Test made on a No. 14 AWG wire with a 93-mil polyethylene coating.
[3] Test made on a No. 14 AWG wire with a 32-mil polyethylene coating.

Blowing agent

The blowing agent used in producing cellular polyethylene is a thermally sensitive chemical which liberates gas at a specific temperature. The correct choice of the blowing agent is a critical one and will depend on the end use for which the cellular polyethylene is intended. If it is to be used, for example, in an electrical application, the blowing agent, the gas liberated by it, and any residual products must not absorb any moisture that will degrade the insulating characteristics of the compound and the blowing agent should liberate a maximum of nonpolar residue so that the low-loss characteristics of the polyethylene insulation will not be impaired. For bottle cap liner applications, the blowing agent and its residues must be nontoxic; in decorative sheets, color stability is an absolute necessity.

Extrusion technique

Extrusion has thus far been the most commonly used method in forming cellular polyethylene. Conventional extruders that can be regulated both as to heat and pressure have been successfully used to process the material. It must be remembered, however, when handling cellular polyethylene, that the extruders must also function: 1) by applying heat that will cause the blowing agent to liberate the expanding gas; and 2) by maintaining uniformly high pressures in the barrel, head, and die so that premature expansion of the liberated gas before the material emerges from the die will be prevented.

Optimum conditions for extrusion will, of course, vary with the particular extruder, the size of the extruded article, and the blowing agent. Some points that can be taken into consideration, however, are: 1) operating temperatures that are too high will give less uniform bubble size and a rougher surface with accompanying cooling problems; temperatures that are too low result in high-density material; 2) dies that develop a minimum pressure of 1000 p.s.i. are adequate for wire insulation but 2000 p.s.i. is more satisfactory; 3) high pressures can be maintained by using double- or triple-tapered dies to lengthen the overall die length (to ensure smooth surfaces, land lengths equal to the diameter of the die are considered maximum); and 4) since cellular polyethylene doubles in volume, the area of the die opening minus the area of the wire or core should be 50% of the area of the finished insulation.

For applications where higher densities are required, cellular stock can be blended with a solid polyethylene compound. Higher densities are also obtained by extruding at reduced temperatures, thus limiting the extent of blowing. Results, however, are extremely difficult to reproduce and it is therefore recommended that all gas be liberated from the blowing agent during extrusion.

Screw temperature control to prevent overheating of compounds is necessary when extruding wire and cable insulation. Temperatures ranging from 20 to 100° C. have been used successfully; the exact desirable temperature varies with the extruder. A screw length-to-diameter ratio of 12:1 or higher is more effective than lower ratios while a high compression-ratio screw is preferred to a low compression ratio screw of the same type. Screws of the constant-pitch, variable-depth type with a 3:4 flight metering section, are found most satisfactory. Preheating the wire or core

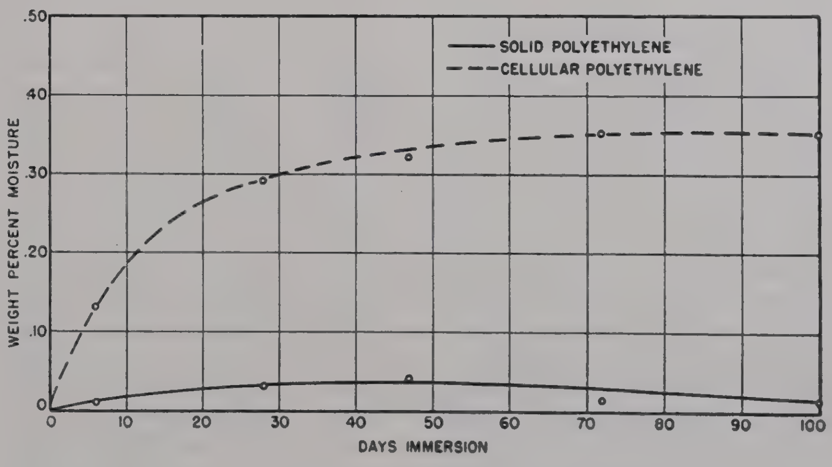

FIG. 1: Water absorption is plotted against water immersion time for solid polyethylene vs cellular polyethylene materials

to between 100 and 125° C. is desirable for achieving a smooth, regular surface. Lower temperatures tend to give a lumpy material; higher temperatures result in uneven cooling and flattening of the insulation.

It is possible to use direct water cooling for thin-walled insulation but heavy walls require a long stretch of air cooling. If the product is quenched too rapidly, it will flatten, due to the weakness of the extruded coating at the extrusion temperature. Another cause of insulation deformation is the contraction of the occluded gases before the polyethylene has had an opportunity to develop strength. It is possible, however, to minimize these tendencies by using the lowest compound temperatures that will give complete blowing and good forming behavior.

FOAMED PHENOLICS

Essentially, there are two types of phenolic foam available commercially—foam which is produced in the conventional manner by a chemical reaction between resin and ingredients, and "premixed" foams or "syntactic foams," as they are also known, based on hollow phenolic spheres bonded together with such resins as polyester or epoxy in much the same way as cement binds gravel to form concrete.

Reaction-type foams

Techniques: This type of foam results from the utilization of the "built-in" heat of reaction of the phenolic resin to cause vaporization of the small amounts of water and solvent present in the mixture of resin, catalyst, and certain modifying agents. During the foaming process, the resin changes rapidly from a free-flowing liquid to an infusible cellular solid. A proper balance of reaction and expansion results in the formation of a foam having a volume as much as 200 times greater than the original liquid resin.

In a typical foam formulation, a wetting agent, e.g. Tween emulsifier No. 40 (Atlas Powder Co.), isopropyl ether, and a catalyst are mixed with the liquid phenolic resin. These components are combined and beaten with an agitator so that many small air bubbles are introduced into the resin. These bubbles serve as "seeds" for the foam formation and increase the liquid resin volume as much as 20 percent. When the volume of the solution has increased about 20%, the mixture is brought to 77° F. and acid catalyst, also at 77° F., is added to the foamable resin.

The mixture is then agitated violently with a propeller-type stirrer for 5 sec. and immediately poured into the foaming container. The material will foam in 7 to 8 sec. after adding the acid catalyst.

Catalyst concentration and temperature of ingredients may be varied to influence the speed of the foaming reaction. Higher-density formulations made with blends of phenolic resins react more slowly than do the low-density formulations.

Since the entire operation from the introduction of the acid catalyst to the formulation of a fully expanded block of low-density foam is completed in about 45 sec., a cycle controller to initiate automatically the various steps in the process is highly desirable.

Properties

The most important characteristics of reaction-type phenolic foam are light weight, high stability, heat resistance up to 250° F., and nonsupport of combustion. It is also among the most inexpensive of plastics foaming materials. Since a composite structure, about 40 to 60% open and closed cells, is formed during foaming, phenolic foam is a good thermal insulator with some acoustical insulating properties as well.

In practice, phenolic can be foamed to densities ranging from ⅓ lb./cu. ft. all the way up to the density of nonporous resin which is about 80 lb./cu. foot.

Phenolic foam has its best thermal insulating value (a "K" value of 0.18 B.t.u./in./ft.^{2}/°F./hr.) at a density of about 2 lb./cu. foot. However, a low-density foam does have better insulating properties when mechanically compressed to higher densities. Such action increases the number of air cells in an inch of thickness and consequently lowers the "K" factor.

Since increasing the density, either chemically or mechanically, increases the cost factor, it should be noted that a foam density of ⅓ lb./cu. ft.—with a "K" factor in the order of 0.26 to 0.28—is still within the range of insulation provided by conventional materials.

Applications: The good insulating qualities of phenolic foam coupled with the development of improved installation techniques has increased the value of the foam for building insulation. The reaction-type foam can be installed by: 1) filling wall spaces with precut, factory-produced slabs; 2) foaming the material into horizontal prefabricated panels and structures on a moving conveyor belt; and 3) foaming-in-place operations right on the building site.

By using carefully prepared formulations and by carrying out the reactions at high speeds (e.g., an 8-ft. wall cavity about 4.3 cu. ft. in area, can be filled in less than 60 sec.), the phenolic resin will foam in a vertical wall cavity to controlled heights, at whatever insulating density is desired, and with uniform density throughout the structure. The foam permanently bonds itself to the wall, providing no-sag insulation.

Since the foam does not act as a vapor barrier, a separate material such as plaster board backed with aluminum foil, or polyethylene film, should be added. To handle a continuous foaming operation, special mixing equipment is necessary. Equipment of this kind is being made available commercially.

In addition to thermal insulation, reaction-type phenolic foam can also be used as a handicraft material. Smooth surfaced and easily cut with simple hand tools, the foam can be sandpapered, coated with a pore-sealing solution, and formed into vases, bowls, trays, desk sets, and other items,

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This article was prepared by Union Carbide Plastics Co., Div. Union Carbide Corp., 420 Lexington Ave., N.Y. 17, N.Y.

with an appearance similar to carved stone.

Normally resistant to water penetration, phenolic foam can, however, be made to be readily water-absorbent. Blocks of the material, so produced, form highly useful bases for cut flower arrangements by keeping flowers moist and fresh while eliminating problems of spillage. Water-absorbing foam blocks also make excellent cigar-counter humidifiers.

Other specially produced and colored phenolic foams are finding wide acceptance as lightweight decorative materials.

Syntactic foams

Technique: In practice, syntactics are made by combining hollow, microscopic phenolic spheres with either phenolic, epoxy, or polyester resins in much the same way cement and gravel are mixed to form concrete. When thus made, the phenolic balloons produce a foamlike, low density, cellular composite. Putty-like in consistency, the uncured foams harden into a material of high strength and light weight. Foams varying in density from 10 to 40 lb./cu. ft. can be simply and quickly produced by varying the proportion of resin binder to the phenolic spheres.

The following formulation procedure is typical of various types of syntactic foams:

(EPOXY BINDER)

Composition	*Parts by weight*
Epoxy resin ERL-2795	30
Epoxy hardener ERL-2793	9
Phenolic spheres BJO-0930	120

Procedure: Add a weighed amount of epoxy resin to a kneader-type mixer. With agitation, add the proper amount of epoxy hardener. Gradually add the phenolic spheres to the mix and continue mixing until a thick, putty-like mass is obtained. This mass may then be hand-troweled into place and cured at room temperatures. Temperatures up to 212° F. accelerate cure. A foam density of 8.6 lb./cu. ft. results.

Properties: The spherical cell shape brings to syntactic foam one of the highest strength-to-weight ratios of all plastics foams, along with good insulating qualities. In addition, the ease with which it can be handled without the need for special equipment makes it one of the most useful of foamed-in-place materials, particularly for do-it-yourself applications.[1]

Normally handled as a putty-like mass, the syntactic foam can be troweled onto suitable surfaces (preferably with some form of heated trowel), molded to shape, forced into cavities, or pressed into sandwich core structures.

Applications: Perhaps the greatest potential for syntactic foam is as a core material in sandwich-type structures. Syntactic foam materially reduces the flexibility of reinforced plastics with negligible increases in weight. Experimental sandwich structures consisting of cores of phenolic spheres, polyester resins, and loose fibrous glass strands between fibrous glass mats show flexural strengths ranging from 1700 to 4500 p.s.i., tensile strengths between 1600 and 2900 p.s.i., and compressive strengths as high as 12,100 p.s.i.

The foam is therefore finding use as a core material for such reinforced applications as boat hulls and decks and reinforced sections of airplane structures.

Syntactic foam can also be used for simple do-it-yourself repairs on wood structures in homes or industry. Rotted-out wood can be repaired by troweling the foam into the area and letting it cure, or set, until it is hard. The use of epoxy resin as the binder in the foam contributes to its ability to cure without any need for special equipment.

Either as a cast material for repairing wood or as a core material for sandwiches, the syntactic foam can be easily sawed, painted, or drilled.

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[1] The best sources for information on syntactic foam for do-it-yourself applications are the compounders of this material: Palmer Products, Inc., Worcester, Pa., and National Engineering Products, Inc., 15th & New York Ave., N.W., Wash., D.C.

CELLULAR CELLULOSE ACETATE

By P. J. Witte*

Expanded cellulose acetate, known, to industry as cellular cellulose acetate (CCA) or Strux, is a uni-cellular product produced by a continuous extrusion process wherein molten cellulose acetate is converted into a rigid foam by the flash vaporization of a volatile solvent. CCA is strictly an extruded product and cannot be foamed-in-place. It is presently available in the form of boards (in sizes of 1 by 4, ¾ by 6, ½ by 8, and 1¼ by 4 in.) and 2¼-in. dia. rods and in the density range of 6 to 7 lb./cu. foot. The cross-sectional area of the stock shapes is, of course, governed by the capacity of the extruder and is, at present, 6 sq. inches.

Since a rather dense, smooth skin is present over the entire surface of CCA as extruded, boards are passed through parallel circular saws which remove the edge skins and establish the width dimensions. Removal of the skin on all faces results in an over-all density decrease of 1 lb./cu. foot.

CCA is noted for excellent strength properties, resistance to attack by vermin and fungi, and thermal stability (see Foamed Plastics Data Chart, p. 513). It may be subjected to temperatures as high as 350° F. for extended periods and up to 380° F. for short periods, without decomposition. Mechanical properties are not greatly affected by temperature change. At —70° F., room temperature values are decreassed approximately 20 percent. The coefficient of linear expansion of 2.5×10^{-5} in./in. for 1° F. and a thermal conductivity of 0.31 B.t.u./hr./ft.^{2}/°F./in. of thickness further indicate good thermal properties. CCA has a burning rate of 4.9 in./minute.

The water absorption of CCA, expressed in terms of reserve buoyancy after complete immersion in water, indicates an initial buoyancy of 55 lb./cu. foot. This value is reduced to 53 lb. after 24-hr. immersion. Four days of subsequent immersion decreases the buoyancy to 52 lb./cu.ft., at which point stabilization is obtained.

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*Director of Research, Russell Reinforced Plastics Corp., 521 W. Hoffman Ave., Lindenhurst, N.Y.

Drying results in complete recovery of original buoyancy.

Fully cured CCA is a rigid, white foam with no odor. Toxicity has been thoroughly investigated. The basic ingredients are known to be nontoxic. No volatile or unstable components are formed with an increase in temperature, pressure, or moisture.

Applications

CCA is used extensively as a core material in sandwich constructions. In other fields, it has found acceptance as reinforcement for aircraft control surfaces, radome housings, and filler blocks under fuel cells. Inert to various fuels, it has been used for years to make floats for indicating devices. Its buoyancy has led to its use in life-floats, buoys, and other marine flotation devices, as well as installation for permanent buoyancy in small craft. Its dielectric qualities have made it useful in the manufacture of X-rays and other electronic equipment. Other applications include ribs, posts, and framing members in shelters, housing units, trailers, and other similar large structures.

One of the most extensive uses for CCA has been as gun-port plugs for military jet aircraft. It has also been used in an experimental packaging unit for shipment of anti-personnel mines and detonators. It is similarly useful as a protective covering for batteries.

Fabricating techniques

CCA is easily machined to extremely close tolerances by ordinary woodworking tools. It is important to note that strengths are maintained through these operations even though skin surfaces have been removed.

It is sometimes required in certain applications manually or mechanically to shape CCA sections to a particular contour. Extruded parts have reasonable flexibility in the direction of extrusion and can be formed in large radii and simple curves, especially in thin sections after skin removal. Flexibility can be increased to a degree by subjecting the piece to hot water or steam for short periods. Dry heat is not effective.

Simple gluing procedures work well with this material. Fabricators have used polyester and epoxy resins, particularly where vertical surfaces are encountered, using thixotropic or thickened resin mixes which have little tendency to flow or run due to gravity. Also used are phenol-, urea-, and resorcinol-formaldehyde-type adhesives.

Single-component systems

Single-component systems such as those offered by the vinyl- and rubber-base cements are more satisfactory on small-scale operations. Besides elimination of mixing, these types are usually lower in cost and, even more important, have almost unlimited pot life in a closed container.

One of the most important applications of CCA is, of course, as a core in sandwich constructions. This can be done either by primary or secondary bonding. In primary bonding, the CCA core is merely laid contiguously between resin-impregnated facing materials and placed in a press under a pressure of about 30 p.s.i., for required cure time at required temperatures. Secondary bonding requires roughening the surfaces of the facing and using the gluing techniques mentioned above.

FOAMED SILICONES

By D. E. Weyer*

Originally, silicone foams were shipped in the form of crumbled solids. The end user melted the resin, added an amine catalyst and a nitrogen-evolving blowing agent, poured the mixture in place, allowed it to expand, and then cured it with heat.

In 1953, these materials were replaced by a series of premixed powders which melted and foamed simply through the application of heat. The finished foams were stronger than the previous materials and densities ranged from 10 to 16 lb./cu. foot.

More recently, a new series of resins were put under development that could expand and cure at normal room temperatures (without the necessity for heat) and which formed rigid foams lower in density (4 to 5 lb./cu. ft.) than the premixed powders.

Still more recent is the development of lightweight silicone rubber foams that can be mixed and expanded in place at room temperature and which possess excellent resilience over a wide temperature range.

Premixed powders

Techniques: The premixed powders are made up in the proper ratios of a silicone resin (a solventless polysiloxane with melting points of 120 to 140° F.), a blowing agent (*Unicel ND*, Du Pont), catalyst, and fillers. To make a foam, the powder is simply heated above 320° F. As the resin liquefies, the blowing agent decomposes, evolving nitrogen gas, which expands the resin while the amine byproducts are catalyzing the condensation of the resin. Expansion and gelation are therefore synchronized, and the resin gels at its point of maximum expansion.

Heating can be accomplished by air-circulating ovens, strip heaters, heat lamps, or similar equipment. The structure should be exposed to the expansion temperature for at least four hours; the foam may then be removed or the temperatures raised in increments of 50 F. degrees for postcuring.

Properties: Typical properties of the three types of silicone premixed powders (R-7001, R-7002, and R-7003, Dow Corning) are listed in Table I, p. 305. R-7001 and R-7002 may be foamed-in-place; R-7003 can be foamed satisfactorily only in block or sheet form, but it is stronger and retains a greater degree of compressive strength at high temperatures than the others. Heat resistance of all three is, of course, excellent and thermal conductivity is low.

Foamed structures of R-7001 are the most resistant to thermal shock. Samples have been cycled repeatedly between room temperature and 600° F. without cracking and have withstood 700° F. for 72 hr. with only slight dimensional change.

Similar to R-7001 in most respects, R-7002 retains a considerable amount of its compressive strength at elevated temperatures, especially if postcured for 48 hr. at 480° F. In many applications, the foam will cure and become stronger with use.

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* Product Engineering Laboratory, Dow Corning Corp., Midland, Mich.

Applications: High-temperature thermal insulation is, of course, a natural for these materials. Originally they were considered as core materials for high-temperature sandwiches but to date have proved too brittle to withstand the vibration encountered.

They are, however, extremely useful as molded components for aircraft and as insulating materials for instruments.

Room-temperature curing foams

Techniques: These foams are formulated as two liquid components which are blended in a high-speed mixer for 30 sec. and poured. The expansion factor is in the range of 7 to 10 times. The reaction is slightly exothermic but temperatures seldom exceed 150° F., even for very large pours. Expansion is complete within 15 min., although the foam will be soft and tender for about 2 hours. After 10 hr., the foam is hard enough to cut and handle.

Hydrogen gas is liberated as the expanding agent. The quantity given off, however, is small and has not presented any explosive hazards. The usual precautions should be taken when large quantities of foam are processed.

Properties: Finished foams have withstood continuous exposure to as much as 600° F. They have excellent flame resistance, low thermal conductivity, good electrical insulation properties, and a low order of water absorption. The heat of reaction and expansion pressure are so low that heavy paper forms can be used. Typical properties are listed in Table I, right.

Applications: Although these materials are not yet generally available, they have already demonstrated their effectiveness as thermal insulation on processing equipment in experimental applications. Steam valves can be insulated in 15 min., for example, by simply building up conventional insulating materials to the

TABLE I: Typical properties of silicone resin foams

Premixed powders

Property	*Dow Corning R-7001*	*Dow Corning R-7002*	*Dow Corning R-7003*
Density, lb./cu. ft.	12	14	16
Cell size, in.	0.08	0.08	0.08
Compressive strength, p.s.i.			
at 77° F.	100	175	325
after ½ hr. at 500° F.	5	25	75
after 200 hr. at 500° F.	25	40	70
Weight loss, %			
during expansion	1.2	1.3	1.0
after 200 hr. at 480° F.	2.1	2.1	2.1
after 200 hr. at 570° F.	4.0	3.2	3.4
after 72 hr. at 700° F.	8.5	5.2	5.2
Water absorption, % by wt., after 24-hr. immersion	3.2	2.3	2.1
Heat distortion temp., °F.	700	700	700
Flame resistance	Does not burn	Does not burn	Does not burn
Thermal conductivity[1] B.t.u./in./°F./sq. ft./hr.	0.3	0.3	0.3
Dielectric constant[2] (8.5×10^9 cycles/sec.)			
at 70° F.	—	—	1.26[3]
at 500° F.	—	—	1.37
at 77° F., 24 hr. wet	—	—	1.27
Available density range, lb./cu. ft.	10–14	12–16	14–18

Foams expanded and cured at room temperature

	Rigid	*Semirigid*
Density, lb./cu. ft.	3.5	3.5
Compressive strength, lb./sq. ft.		
at room temp.	900	280
at 500° F.	72	—
at room temp. after 200 hr. at 500° F.	1152	500
at room temp. after 24 hr. at 700° F.	1020	320
Weight loss after 200 hr. at 500° F., %	6.4	7.6
Volume loss after 200 hr. at 500° F., %	8.3	9.1
Top service temp., continuous, °F.	650	650
Water absorption, lb./sq. ft. surface area	0.284	0.284
Moisture vapor transmission, perm. in.	41.2	41.2
Thermal conductivity, B.t.u./°F./hr./in. thick/sq. ft. at 77° F.	0.281	0.281
Flame resistance, Lp 406 Method 2021-1	self-extinguishing	self-extinguishing
Dielectric constant at 10^5 cycles	1.09	1.10
Loss tangent at 10^5 cycles	.0028	.0103
Closed cells, %	60 (estimated)	60 (estimated)

Silicone rubber foams expanded and cured at room temperature

Density lb./ft.[3]	13-15
Thermal conductivity, B.t.u./°F./hr./in. at 77° F.	.31
Color	Tan
Weight loss, 200 hr. at 250° C.	8.6
Volume loss, 200 hr. at 250° C.	5.9
Compression set 22 hr./25° C.	0
170° C.	105
Dielectric constant 10^5 cycles/sec.	1.27
Power factor 10^5 cycles/sec.	0.0013
Dielectric strength v./mil	59
Volume resistivity	8.7×10^{12}
Surface resistivity	6.2×10^{12}
Compressive deflection at 25%	2.5
at 50%	5.0
Tear strength, p.s.i.	2.5
Tensile strength, p.s.i.	15
Elongation, %	50

[1] At 11 lb./cu. ft. density. [2] At 13.3 lb./cu. ft. density. [3] All three powders have essentially the same electrical characteristics. Other powders can be formulated with dielectric constants from 1.2 to 7.0

bottom of the valve bonnet, wrapping the valve in common roofing paper, and pouring the mixed foam components through a hole in the top of the paper form. The paper is left in place after foaming to act as a protective skin. A similar technique, only this time using a sheet-metal form, was used to insulate the 8 ft. long barrel of a plastics extruder in 8 man-hours, as opposed to the 20 required with conventional materials.

Where forms can't be used, the foam can be applied with a catalytic spray gun.

Silicone rubber foams

Techniques: These foams, also made by mixing two components, are available in a range of densities from 5 to 30 lb./cu. foot. While mixing is simple, requiring only 30 sec., the current materials must be poured immediately because of the speed of the reaction. Negligible pressure is generated on the form. Molded parts can be removed within 5 min., although the development of maximum strength requires another 24 hours. By varying formulation and foaming techniques, it is possible to produce either open- or closed-cell foams.

Properties: Typical properties are listed in Table I, p. 305. The adhesion of the foams is excellent when cast against glass cloth or asbestos paper. For adhesion to metals, a primer is recommended.

Applications: The rubber foams are suggested for applications where resilience and low density are desired. They are now under consideration for vibration insulation, for foamed-in-place thermal insulation, and for cushioning around fragile electric components which need protection during their encapsulation in any of the various rigid potting compounds.

FOAMED EPOXIES

Low-density structural materials are now available which have the inherent good properties of the epoxies, namely electrical resistance, durability, water resistance, and resistance to many chemicals. These are supplied either as one or more components for foam-in-place applications or in prefoamed slabs or blocks.

Foam-in-place

An interesting development available from one manufacturer[1] is a free-flowing powder which contains a balanced proportion of all the necessary ingredients to cause foaming and curing by simply heating to a range of 185 to 250° F. The material can be stored for long periods if kept dry. A feature which makes this material of interest to electronics manufacturers is that the material foams slowly upon application of heat. Hence, production use is simplified.

The resulting product can be of low- to high-density (ca. 4 to 40 lb./cu. ft.), depending upon the formulation, and will have physical strength proportional to the density. A 6 lb./cu. ft. foam may have compressive strength of 125 p.s.i. while a 22 lb./cu. ft. foam may have more than 1000 p.s.i. compressive strength.

Some of the applications for such foams include packaging of delicate electronic devices such as magnetic amplifiers or vacuum tubes. Such devices have successfully withstood vibration and shock loadings of 50 G's and up, and vibration frequencies varying from 5 to 500 cycles/second. Flotation is a good potential application due to the closed-cell structure and excellent water resistance of the foam.

The powders used for low- and high-density foams can be mixed in any proportion to provide foam densities at any level between the extremes. Or the density may be increased by confining the material during the foaming operation.

Another interesting modification provides foams of various dielectric constants varying from ca. 1.2 to 4.0 or more. Such materials are suitable for use as high-frequency radar lenses due to the very small uniform bubbles in the foam.

The two-component liquid epoxy foaming resins also available from the same manufacturer have somewhat higher heat distortion points and generally produce a foam of larger cell size. Heat is essential to the reaction between the two components and may be supplied externally or as a result of the preliminary reaction between the agents used. In all cases, postcuring at somewhat elevated temperatures is recommended for developing ultimate properties.

To prevent undue exothermic action, which can cause internal charring, built-in chemical energy absorbers are usually used. Normally, electronic packages have enough thermal mass distributed through their volume so as to reduce the temperature rise to a low level.

An epoxy system is available from at least two manufacturers[2] which utilizes the exothermic energy of the epoxy reaction to cause polystyrene beads to expand considerably in volume. Thus, upon the curing of the epoxy, a rigid composite material of thermoplastic polystyrene beads is produced which is bonded together with the hardened epoxy resin.

Prefoamed blocks

Available from another manufacturer[3] are prefoamed blocks of epoxy resin. These blocks are made by simultaneously foaming and curing an epoxy resin formulation under carefully controlled conditions. Since the final product is thermoset, it is unaffected by solvents, and has a temperature resistance expected of cured epoxy resin. It is classified as a rigid foam and is readily machinable by ordinary woodworking tools. Because of its fine, uniform structure, and complete freedom from grain, it may be carved or machined with great ease, leaving a good surface on which finishing coats may be applied. It has exceptionally good dimensional stability, and pieces fashioned from it show complete freedom from warping and excessive dimension changes on exposure to moderately elevated temperatures and high humidity. The core structure is essentially unicellular, and therefore the material lends itself well to flotation applications.

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[1] Minneapolis Honeywell Regulator Co., Plastics Dept., 2753 Fourth Ave. S., Minneapolis 5, Minn.

References were prepared by the editors.

[2] Dow Chemical Co. and Koppers Co., Inc.

[3] DuRafoam, D & R Plants, Inc., Hazardville, Conn.

The foam itself is naturally cream-colored, with a tendency to turn tan-colored on exposure to light; but when the material is formulated to make the finished structure flame-resistant, the color will be a light metallic gray.

The coefficient of thermal expansion is essentially the same as that of normal cast epoxy resins —about 5 to 6×10^{-5}/°C.

In its behavior under load at elevated temperatures, the material exhibits a yield point of around 100° C.

Yielding of the material at elevated temperature is of a rubbery nature, indicating the basically gelled cross-linked structure of the resin. The deformation is recoverable.

The ability of the foam to move without crushing at elevated temperature enables one to postform the material into simple or complex curvatures, as needed. To do this the foam must be uniformly preheated to 250 to 300° F. Thin sections will heat up fairly quickly, but thicker sections should be allowed to heat for longer periods to compensate for the insulating qualities of the foam. The forming surface should also be at the same temperature as the foam, and the foam should be pressed to the desired contour without any exposure to cooling air. For best results, both the form and the foam should be heated in the same oven. After postforming, the foam should be cooled in place to a temperature of about 100° F. before freeing it from the mold. Because of the tendency towards elastic recovery, postformed materials should not be heated again above 180° F. unless restrained.

To illustrate the basic dimensional stability of the foam, a cube approximately 2 in. was heated for 24 hr. in an air-circulating oven at 350° F. The average change in each of the three dimensions of the cube indicated an average shrinkage of only 2.4% or a volume shrinkage of only 7 percent. Larger blocks, of course, would be expected to show a smaller shrinkage because of the lower surface-to-volume ratio. Samples exposed ten days at 100% relative humidity and room temperature showed no appreciable change in weight or dimensions.

Applications: Large foam blocks available in sizes up to 1 by 2 by 6 ft. are finding particular utility in tool rooms where they are excellent basic materials for templets, check fixtures, and models. They can be machined and finished to an accuracy greater than that obtainable with the best grade hard wood and will hold their dimensions because they are unaffected by humidity. They are markedly free from warping and twisting because of their freedom from grain or non-uniform areas. In the heavier densities they are very hard and strong, and this may be further enhanced by coating them with epoxy resins or polyester resins, either with or without fibrous glass reinforcement.

Another suggested application is the making of building panels in which 2 by 6 ft. panels of any desired thickness may be coated on one or both sides with decorative skins, employing either polyester resins or epoxy resins; or aluminum foil may be bonded to the surface of the foam by any of the conventional adhesives. Because of the large sizes of foam blocks available, the necessity for bonding blocks of foam together to make large specimens is considerably reduced, but in those cases where it is needed, any of the conventional adhesives may be used; epoxy adhesives are particularly recommended.

References

Consult the Subject Index for additional information concerning foamed plastics and foaming agents. See also the Foamed Plastics Chart for information on properties and trade designations. For sources of foamed plastics, see Directory Index, p. 1078.

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VINYL FOAMING AGENTS

By R. E. Mortberg[*] and R. T. Cady[†]

Almost a dozen cellular plastics have been introduced commercially within the past decade. Those based on polyvinyl chloride occupy a unique place relative to the other foams because they offer a much greater variety of formulations, properties, and uses. Vinyl foams covering a wide range of properties can be made by relatively simple techniques. The contrasting types possible include open- or closed-cell products which may be resilient, nonresilient, semirigid, or rigid in

(*Continued on p.* 310)

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[*] Diamond Alkali Co.

[†] E. I. du Pont de Nemours & Co., Inc.

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Graphic Outline of Typical Urethane Formulations

PROPERTY	CLASSIFICATION	TRADE NAME	TYPICAL APPLICATIONS
Polyester (Freon Application)	Rigid	Stafoam	Insulation for all types refrigeration and air conditioning
Polyester	Rigid	Stafoam	Low density insulation, structural materials, void fillers and sealants
Polyester	Flexible (available in colors)	Stafoam (S-600 series)	Insulation, sound deadening, auto headliners, gasket seals, etc.
Polyether	Flexible (sheets or slab, white only)	Stafoam (S-220 series)	Seating, cushioning, padding, etc.
Urethane Rubber	Flexible molding compound	Polyrubber	Packaging (High Density)
Urethane Elastomer	Solid	Daycollan	Silent gears, printing rollers, footwear, athletic equipment, etc. (See Footnote Below)
Polyester & Polyether	Rebonded Flexible	Statex	Sound Absorption
Polyester	Flexible	Filter Foam	Automotive, aeronautical and industrial air filters
Urethane Potting Compound	Solid (Cast)	Polypot	Electrical encapsulating compound with low dielectrics

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nature. Formulation and process technology are advancing at a rapid pace and promise to open large markets to these versatile foams within the near future.

The two basic methods of making vinyl foam are the mechanical and chemical processes. The mechanical process (see p. 294) introduces gas, usually carbon dioxide, into the vinyl system under pressure (1,2)[1]. The chemical process discussed below involves the addition of a thermally unstable compound, called a blowing agent, to the vinyl formulation. When heated or chemically activated this agent decomposes with the evolution of a large volume of gas, usually nitrogen. The process may be carried out either at atmospheric pressure or in a pressurized system.

Blowing agents vary widely in their chemical nature. The earliest types were used in the rubber industry and included such simple inorganic salts as ammonium carbonate and sodium bicarbonate. Others include ammonium nitrite sodium borohydride (3), and the reaction of alkali on aluminum (4). Most chemically blown vinyl foam, however, is expanded with the organic agents because they usually are more versatile and more easily controlled. Table I, below, lists those which are of greatest commercial importance.

Factors that govern the selection of a blowing agent are:

1) Temperature and rate of decomposition; 2) effect of other formulation ingredients on the decomposition characteristics; 3) properties such as color, toxicity, and odor which are important in the end product; 4) type of cell structure desired; and 5) method of processing.

Chemical blowing agents will expand plastisols as well as nonfluid vinyl compounds. In selecting the appropriate agent, the most important consideration is decomposition temperature. By suitable techniques, blowing can be made to take place at any one of the following five stages which represent the different levels found during processing:

1) Before heat is applied (by activation at room temperature); 2) prior to gelation (140 to 250° F.); 3) between gelation and fusion (250 to 320° F.); 4) during fusion (320 to 350° F.); or 5) after fusion (350 to 400° F.).

As a general rule, blowing prior to gelation produces an open- or interconnected-cell structure. Blowing between gelation and fusion usually produces a mixture of open and closed cells. If blowing takes place during or after fusion, the cell structure is predominantly closed.

Foam density is governed by blowing agent concentration and to some extent by formulation. However, certain blowing agents perform more efficiently than others, depending upon the stage at which blowing occurs. For instance, in processes involving free expansion at atmospheric pressure the lowest densities are usu-

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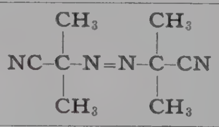
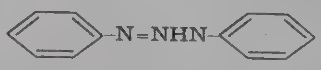
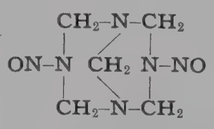
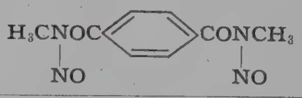
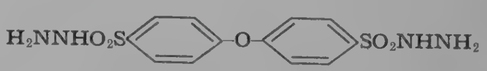
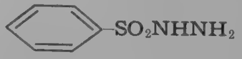
[1] Numbers in parentheses link to special references on p. 314.

TABLE I: Principal commercial organic blowing agents

Gas generant	*Trade name*	*Manufacturer*	*Formula for gas generant*	*Decomp. range °F*
α,α′-azobis (isobutyronitrile)	Genitron-AZDN Porofor-N	Whiffen & Sons Ltd. Bayer	 $NC-C(CH_3)_2-N=N-C(CH_3)_2-CN$	203-216
1,1′-azobis (formamide)	Celogen-AZ Genitron-AC Kempore R-125 Porofor-505A	Naugatuck Chem., Div. U. S. Rubber Whiffen & Sons Ltd. National Polychemicals Co. Bayer	$H_3NOCN=NCONH_3$	374-392
Diazoaminobenzene	Porofor-DB Vulcacel-AN	Bayer Imperial Chemicals Ind.		212-320
N,N′-dinitrosopentamethylenetetramine	Unicel ND Vulcacel-BN Opex 40 & 80	Du Pont Imperial Chemicals Ind. National Polychemicals Co.		356-392
N,N′-dimethyl-N,N′-dinitrosoterephthalamide	BL-353	Du Pont		194-221
p,p′-oxybis (benzenesulfonyl hydrazide)	Celogen Genitron-OB	Naugatuck Chem., Div. U. S. Rubber Whiffen & Sons Ltd.		284-320
Benzene sulfonylhydrazide	Genitron-BSH Porofor-BSH	Whiffen & Sons Ltd. Bayer		212

ally obtained where the agent decomposes at a relatively low temperature and blows before gelation has occurred.

With compounds which are not fluid, such as gels, powders, flakes, or cubes, blowing generally occurs during or after fusion, resulting in a closed-cell product. Such compounds are processed in a pressurized system.

A given blowing agent is not necessarily limited to only one narrow temperature range. It is possible, particularly with those having high decomposition temperatures, to employ chemical activators which make the blowing agents effective over a wider temperature range.

Formulation techniques also exist for increasing or decreasing the gelation and fusion rates of vinyl systems. In certain processes, the environmental conditions—temperature, rate of heating, and pressure—can be regulated so that blowing will occur at any one of the five stages. In the case of pressurized processes, the choice of agents is quite broad because the environment over-rides any vast differences in decomposition characteristics. When there is such a wide choice of agents, the ultimate selection depends on blowing efficiency, economics, end-use properties, and handling characteristics.

Preparing the compound

All chemically blown vinyl foam is produced from essentially the same type of compound containing, in general, the following ingredients:

Vinyl resin	100 parts
Plasticizers	20-130 parts
Stabilizers	2-10 parts
Additives	Variable
Fillers and extenders	Optional
Blowing agent	Variable

The interchangeability of blowing agents in a particular composition is limited and, consequently, new formulations are best investigated on an individual basis for each agent. Vinyl resins for atmospheric blowing are usually limited to paste or dispersion-grade PVC homopolymers. Pressure-blown vinyl allows somewhat wider choice of resins. General purpose vinyl resins, vinyl copolymers, and blends of vinyl resins with elastomeric materials (5) have been employed.

It is the plasticizer system that gives the formulator the most leeway in controlling foam properties and, to some extent, the processing variables. Every foam property depends at least partially on the plasticizer system. The plasticizer level governs physical properties, such as flexibility, compression modulus, tensile, and elongation; the chemical nature affects other properties, such as permanence, odor, color, and cell structure. Through discrete selection of plasticizers, the experienced compounder can tailor compound characteristics such as viscosity, gelation, and fusion rate to make most efficient use of the blowing agent as well as the processing equipment.

Stabilizers prevent degradation of the vinyl resin by heat and light. They sometimes serve as activators to lower the decomposition temperature of the blowing agent or as surface active agents to promote uniform blowing and fine cell formation.

Additives are used for a variety of purposes and include surface active agents, blowing agent activators, flame retardants, deodorants, pigments, reinforcing fibers, and cross-linking systems. The latter term refers to special additives for making semirigid or rigid foams. An effective additive for this purpose is an aromatic dianhydride (pyromellitic dianhydride) which is used with polymeric epoxidized plasticizers (6). The dianhydride cross-links with the epoxy during fusion; the relative amounts of these two materials control the degree of rigidity in the vinyl foam. Another cross-linking method employs a polyglycol dimethacrylate as a plasticizer (7). Organic peroxides are added to initiate the polymerization of the dimethacrylate at the fusion temperature.

Fillers and extenders sometimes make it possible to reduce foam costs on a weight basis. These materials must be used with discretion, however, since blowing efficiency may be seriously reduced, offsetting any saving. Also, some blowing agents can tolerate only very small amounts of fillers.

Conventional rotary or planetary-type mixers may be employed for blending all ingredients. In order to insure uniform cell structure, milling or a similar dispersing technique is recommended for blowing agents which have variable particle size or have a tendency to agglomerate. Where the ultimate in dispersion is required, it is best to pass the compound over a three-roll paint mill.

A cold, two-roll rubber mill can be used for compounds that are not fluid, usually those having plasticizer concentrations of about 40 phr or less. A heated rubber mill or a Banbury type mixer can be used if the decomposition temperature of the blowing agent is sufficiently high. Powder mixes like those used in extrusion are made by adding the blowing agent to the finished compound by simple mechanical blending.

Atmospheric blowing

Atmospheric (free) blowing techniques have been developed for making moldings, roto-moldings, slab stock, and coatings. Small, molded products such as gaskets and seals having densities from 12 to 25 lb./cu. ft. can be made in a single stage process. Foaming and fusion take place simultaneously during a single-stage heating cycle, usually at a temperature between 325 and 425° F. For these products, blowing agents with either high or low decomposition temperatures may be employed.

The molding process is somewhat more involved for making low-density products (below 8 lb./cu. ft.) and for large items such as seat cushions. Low-temperature agents are employed and two heating stages rather than one are necessary. Foaming is carried out usually below 220° F., followed by fusion in the 325 to 425° F. range. One low-temperature agent—N,N'-dimethyl-N,N'-dinitrosoterephthalamide (8,9)—is particularly useful for producing low-density foam.

An integral vinyl skin can be formed on the molded items by first slush molding or rotocasting a plastisol (without a blowing agent) on the surface of a hot

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mold cavity. After this skin has gelled, the foam plastisol is charged to the mold and the process is finished in the normal manner. The skin and foam become bonded during the fusion stage.

Rotocasting techniques may also be used to produce relatively complex shaped hollow foam articles with or without an integral skin. One technique involves rotocasting a foam plastisol onto the surface of a mold heated to about 325° F. After the vinyl fuses, the temperature is raised to accomplish blowing. This process, of course, requires high-temperature agents such as N,N′-dinitrosopentamethylenetetramine and 1,1′ azobis(formamide); the foam is relatively high in density and consists predominantly of closed cells. A second process uses a low-temperature blowing agent and produces a lower density, more open-cell product. With this method, a mold heated to about 230° F. is filled completely with plastisol and allowed to stand for a few minutes. The actual length of time determines the thickness of plastisol gelled on the mold surface. The excess plastisol is then discharged and foaming and fusion take place at 350° F.

Slab stock vinyl foam can be made in either a continuous or a batch process and is generally produced at thicknesses greater than one inch. The process involves at least two heating stages and generally uses low-temperature blowing agents. Decomposition and foaming take place in a low temperature zone—190 to 220° F.—and fusion is achieved by further heating at about 350° F. Conventional gas-fired, electrically heated, or infra-red ovens are employed. For slab thicknesses exceeding 2 in., however, dielectric heating must be used to achieve complete fusion because of the good thermal insulating properties of the foam. A relatively new technique of plastisol preheating (10), which involves installation of a continuous heat exchanger prior to the foaming stage, will speed up foaming significantly. This technique has cut over-all process cycles as much as 60 per cent.

Continuous foam sheets up to ½ in. in thickness can be coated on such materials as paper, fabric, film, or metal. The plastisol is applied by reverse-roll or knife-coating techniques to the substrates. Both the foaming and fusion operations can be finished in as little as 90 sec. by single-stage heating at around 400° F. In this rapid process, foam density, cell structure, and other properties depend very much on the blowing agent. As before, a low-temperature agent produces a lower density, open-cell product; the high-temperature blowing agents produce higher density foams having more closed cells.

Several interesting techniques have been developed to modify the surfaces of these sheets and coatings. Fiber flocs applied to the "wet", unfoamed plastisol film become firmly bonded to the foam after fusion. They give the surface an attractive, velvet-like appearance and hand. A suede-textured surface can be obtained by sprinkling ordinary table salt on the wet plastisol film surface (11). After foaming and fusing, the salt is washed out by water, leaving a foam having good porosity and breathability. Attractive, three-dimensional embossed patterns can be molded directly into a coating surface. This is accomplished by allowing the plastisol to foam up to or through a perforated metal grid placed just above the surface. The advantage of this method over embossing by heat and pressure is that of obtaining uniform density throughout the foam.

Pressure blowing

Pressure blowing, or compression molding as it is sometimes called, has relatively little in common with the various atmospheric techniques. Plastisols or nonfluid vinyl compounds can be used and the product is always predominantly closed-cell. In the first of the two stages required, the composition is heated to about 350° F. in a closed mold confined under high pressure, usually in a hydraulic press. Both decomposition of the blowing agent and fusion of the vinyl occur during this cycle. The high pressures developed within the mold (usually over 4000 p.s.i.) cause the disso-

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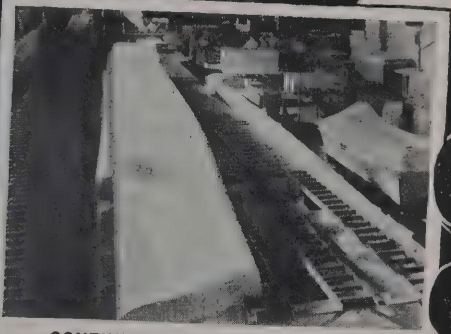
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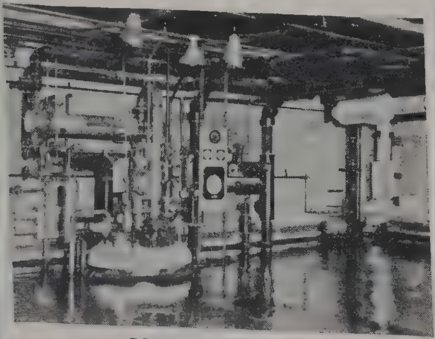
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Newark, N.J. • Harrison, N.J. • Richmond, Calif. • Cedartown, Ga. • London, Canada lution of gas into the vinyl. After the fused composition is cooled, the pressure is released, at which time partial expansion occurs. Expansion is completed by heating again at a lower temperature, 220 to 230° F. High internal stresses which develop during processing may cause these closed-cell products to shrink somewhat upon aging. Some manufacturers are able to improve dimensional stability by annealing, through special formulations, or by means of other and undisclosed techniques.

Foam extrusion

Two processes have been announced for making vinyl foam extrusions; one of these is a direct extrusion method (12) and the other a post-expansion technique (13). Both methods result in essentially closed-cell foam. In the direct extrusion method, the blowing agent decomposes within the barrel of the extruder and the vinyl expands immediately upon emerging from the die orifice. Both high- and low-temperature blowing agents can be used with this method. The post-expansion technique involves extruding below the decomposition point of the blowing agent. After extrusion, heating to a higher temperature decomposes the agent and expands the product. Only those blowing agents having relatively high decomposition temperatures can be used with this method.

The calendering process (13) is similar to the post-expansion technique. The vinyl compound containing a high temperature blowing agent is calendered to the desired film thickness. Then as before, post-heating at a higher temperature decomposes the blowing agent and causes expansion. The resulting product is predominantly closed-cell.

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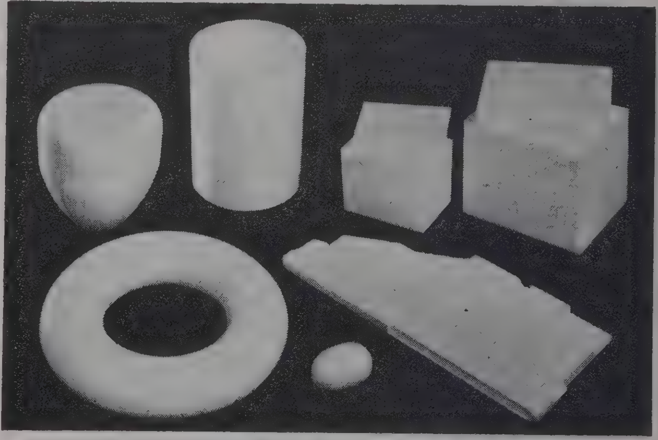

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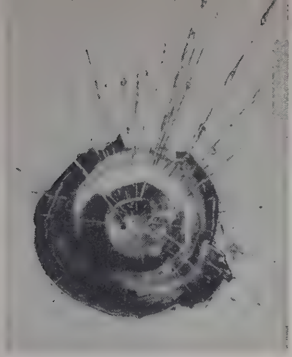

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CHEMICALS AND ADDITIVES

Basic chemicals for plastics

By James M. Church*

Starting materials for production of plastics resins are in many instances the same basic raw materials from which many organic chemicals are made. In fact, it is next to impossible to distinguish between organic chemicals and the materials from which plastics resins are made, for they are one and the same. A good example of this is phthalic anhydride, a large bulk organic intermediate used in the production of dyestuffs, plasticizers, and alkyd resins. Therefore, in discussing the utilization of basic materials for synthetic resins, the inter-relationship of plastics intermediates and other organic substances, such as solvents commonly used with plastics, will be stressed. An attempt will be made to emphasize the many related products which originate from the same basic starting material, and find their way into plastics compositions of all sorts.

Chemicals from acetylene

Ever since World War II, when technical missions from the U.S. discovered the acetylenic chemistry of Reppé in Germany, there has been a steady growth of a large group of chemicals produced from acetylene. Many of these are the monomeric forms of some of the most important plastics, such as the vinyls. Others are more basic organic chemicals, such as acetic acid, which is used in the production of simple and polymeric acetate esters.

Production of acetylene: The majority of the acetylene manufactured in this country comes from calcium carbide by a hydration reaction with water. Two standard methods known as the "wet" and "dry" processes are in common use today. The main difference is in the quantity of water employed in the reaction, resulting in the formation of either a lime slurry or a dry lime hydrate, the latter being suitable for reuse in producing the calcium carbide.

Two other processes have recently been developed for the production of acetylene from petroleum or natural gas. One is the Wulff process which involves a pyrolysis of lower paraffinic hydrocarbons such as butane to form the lower unsaturated hydrocarbons, including acetylene. The other, known as the Sachsse process, consists of a partial oxidation of methane of natural gas to form acetylene, carbon monoxide, carbon dioxide, hydrogen and water. The yields and economics of these latter processes are less favorable than with the carbide processes and therefore less competitive.

Organic intermediates from acetylene: There are a large number of common aliphatic organic chemicals which may be made by various reactions, starting with acetylene. Only those which are of major importance to plastics will be mentioned here. The first of these are the acetic acid products which comprise a family of substances derived from acetic acid or its intermediate, acetaldehyde. When acetylene is reacted with water in the presence of acetic acid and a mercury catalyst, acetaldehyde is formed. About 50% of this important intermediate is produced by this reaction. Because of the reactivity of acetaldehyde, many related products may be obtained which include: acetic acid, acetic anhydride, n-butanol, 2-ethyl hexanol, ethyl acetate, butyric acid, and similar compounds, all of which are important to resin production.

Polymer intermediates from acetylene: In addition to the simple organic chemicals mentioned above, a large number of polymer intermediates, better known as monomers, are produced from acetylene. Most of these are of the vinyl plastic group and include vinyl chloride, vinylidene chloride, vinyl acetate, polyvinyl alcohol, polyvinyl acetals, and acrylonitrile. All of these are produced by the initial addition reaction of acetylene with hydrogen chloride, acetic acid, or hydrocyanic acid to form the corresponding monomers of vinyl chloride, vinyl acetate, or acrylonitrile. It is interesting to note that the most common of the vinyl acetals is polyvinyl butyral, the plastic film in safety-glass sandwiches. This plastic is made from two intermediates obtainable from acetylene, namely, vinyl acetate and butyraldehyde.

Another polymer intermediate is melamine, used in the production of melamine resins. It is related to acetylene, for it is derived from calcium cyanamid, which in turn is produced from calcium carbide. In other words, instead of producing acetylene from calcium carbide, the latter is first reacted with nitrogen of the air at high temperatures and converted to calcium cyanamid. This solid material, which resembles calcium carbide, can then be reacted with water and acid to form cyanamid, which can be polymerized to melamine.

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*Professor, Dept. of Chemical Engineering, Columbia University, New York. Recent Developments and References were prepared by the editors.

Chemicals from ethylene

Ethylene, a basic raw material which is obtained from the cracking of petroleum and natural gas hydrocarbons, is equally important for the production of organic chemicals, as well as for polymer intermediates. One of its largest uses is in the production of synthetic ethyl alcohol. It is also the basis for a large group of so-called "petrochemicals," which include such common chemicals as ethylene glycol, ethyl chloride, ether, and many ethyl esters.

Production of ethylene: The production of ethylene is mainly a supercatalytic cracking of lower paraffinic hydrocarbons such as ethane and propane, which are previously separated from the higher hydrocarbons of cracked refinery gas. A typical cracked ethane-propane gas may consist of 25% methane, 15% ethane, 12% propane, 19% hydrogen, 7% ethylene, 6% propylene, and 16% nitrogen, carbon monoxide, carbon dioxide, and minor ingredients. Separation of the gas constituents is an involved process mainly of absorption and low-temperature distillation, with a recycling of the ethane and propane to the cracking unit. The final separated ethylene gas is made to a purity of 99.5 to 99.9%, depending upon the use to be made of it.

Organic intermediates from ethylene: These materials are produced by various reactions with ethylene, which readily adds substances to the ethylenic bond for the formation of a large number of ethylene derivatives. The hydration of ethylene, either directly or via ethyl hydrogen sulfate, is the main method for the production of ethyl alcohol. Ethyl alcohol in turn may be converted by dehydrogenation to acetaldehyde, which serves as a second source of this important intermediate for the synthesis of many aliphatic organic chemicals, as indicated in the above discussion of chemicals from acetylene. In similar manner, ethylene may be hydrochlorinated, using HCl instead of H_2O, thus forming ethyl chloride, another important organic intermediate used in the synthesis of ethyl cellulose. By a combination of oxidation and hydration, known as hydroxylation, ethylene glycol is produced from ethylene. Large tonnage of this chemical is being used in the production of alkyd and polyester resins, besides its better-known use as an antifreeze compound. There are also a large variety of ethyl compounds such as ethyl ether, ethyl acetate, diethyl phthalate, and various other ethyl esters made from ethylene which find their way into plastics.

Polymer intermediates from ethylene: The most important of these plastics is polyethylene. This material is formed by catalytic polymerization of ethylene, either under high pressures and high temperature for the conventional type of polymer, or at low pressures and moderate temperature for the high-density type. For the production of polyethylene, ethylene of high purity is of utmost importance—as high as 99.9+%.

Second in importance of the polymer intermediates is ethyl benzene, the starting material for styrene production. It is made by alkylating benzene with ethylene in the presence of an acid catalyst. Acrylic esters are made from ethylene oxide or chlorohydrin derivatives through reaction with a cyanide to form the cyanohydrin, which in turn is hydrolyzed and esterified. The cyanohydrin intermediate may readily be converted to acrylonitrile, which is widely used in the manufacture of acrylic fibers and as a modifying agent for the formation of many interesting copolymer resins. In the production of ethyl cellulose, ethylene, in the form of ethyl chloride, is used for the ethylation of cellulose.

Chemicals from propylene

Propylene, an important petroleum hydrocarbon, is the basis for the higher C_3 aliphatic organic chemicals used in the manufacture of plastics. Processes employed follow closely those used with ethylene and lead to the formation of similar compounds, many of which are the next

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Constituents of tung oil, sugar cane, and pine gum are being investigated by the University of Mississippi for conversion into chemical intermediates or monomers, such as acrylic esters, acrylamides, vinyl esters, and amides.

Tri-n-butyl phosphine (*TBP*, Chemicals & Plastics Div., Food Machinery & Chemical Corp.) is a strong organic base with good reducing properties and the ability to form coordination compounds . . . shows promise as an epoxy resin curing catalyst, in making vinyl esters, in polymerizing vinyl compounds, and in controlling the polymerization of organic isocyanates.

higher homolog of the ethylene derivatives. Sources of propylene are mainly from the supercracking of propane and butane mixtures in a similar fashion to the formation of ethylene from ethane and propane. After separation of the propylene from the cracked gases, it is distilled to a purity which can be as high as 99.0 percent.

Intermediates from propylene: By similar reactions, propylene can be hydrated, chlorinated, alkylated, cyanated, and polymerized to form a great variety of derivatives. No doubt the most important single organic compound obtainable from propylene is acetone. This is made by first hydrating propylene, in an indirect two-step process involving propyl hydrogen sulfate, to form isopropyl alcohol. The alcohol is then dehydrogenated by an incomplete oxidation with air to form acetone. Over 90% of the acetone which is produced in the United States of America comes from propylene.

The hydroxylation of propylene by a combination of oxidation and hydration leads to the formation of propylene glycols, which are useful ingredients in the synthesis of polyesters.

A group of products known as allyl derivatives have recently been developed and they in turn have been the basis for synthetic glycerine, as well as for the production of allyl ester resins. The reactions involved are numerous, but start with the high-temperature chlorination of propylene to form allyl chloride. Hydrolysis of allyl chloride leads to allyl alcohol from which a variety of allyl esters may be made. Further chlorination of allyl alcohol and subsequent hydrolysis of the glycerylchlorohydrin, is the process by which synthetic glycerine is being produced.

The alkylation of benzene with propylene is the start of the new cumene process for producing synthetic phenol, which yields acetone as a byproduct. The propylated benzene or cumene is oxidized under mild conditions to the peroxide, which is simultaneously hydrolyzed to phenol and acetone.

The polymeric materials being produced from propylene include polypropylene, methacrylates, allyl ester resins, and propylene polyesters. The development of the first commercial process for producing polypropylene, which involves low-pressure polymerization of propylene, was recently announced in this country. Instead of being just another polyolefin in competition with polyethylene, polypropylene, being an isotactic polymer, possesses unique properties which open a gamut of uses from fiber to film. Polymethylmethacrylate is produced from propylene by a process similar to that for making acrylics from ethylene. The procedure starts with acetone as the intermediate, which is cyanated with hydrogen cyanide; the cyanohydrin is hydrolyzed and esterfied to the methacrylic ester.

Chemicals from butadiene

Large quantities of butadiene were produced during World War II for the manufacture of synthetic rubber of the Buna-S type. Since then, research has disclosed many uses for this abundant starting material in the synthesis of organic and polymer intermediates. One of these is the production of hexamethylenediamine, an intermediate for nylon. The conversion of butadiene in this case consists of a series of reactions which include chlorination, cyanation, and hydrogenation to form the diamine. Another use is in the formation of copolymers with styrene, acrylonitrile, vinyl chloride, and other monomeric substances, where limited amounts of butadiene impart flexibility to the polymer.

Chemicals from methane

Methane, main constituent of natural gas, is becoming increasingly important as a basic raw material for organic intermediate production. "Coal, water, and air" for the synthesis of organics has today given way to "methane, water, and air" for the synthesis of a great variety of aliphatic chemicals. Synthetic methanol is being produced at a rate of over a billion pounds a year from "synthesis gas," which is carbon monoxide and hydrogen. The preferred source of this starting material is from the high-temperature hydrolysis of methane which forms an excess of hydrogen; the older "water gas" from the reaction of coke and steam was deficient in hydrogen. The reaction of carbon monoxide with hydrogen not only forms methanol, but also a variety of other alcohols, esters, ketones, etc., and is carried out at high temperature, high pressure, and with selective catalysts. The greater part of the methanol is used in the production of formaldehyde by an incomplete air oxidation process. Formaldehyde is an important plastics intermediate for the production of phenolic and urea resins, as well as in casein, soybean, and zein plastics. In the anhydrous form it serves as the monomer in the synthesis of the new polyformaldehyde plastic resin known as Delrin.

Synthesis gas is also used in the production of urea for both plastics and fertilizers. The synthesis gas (CO and H_2) is further hydrolyzed at high temperatures over an iron catalyst to form additional H_2 and CO_2. These are separated by absorption of the latter in cold water under pressure. The hydrogen is utilized in the synthesis of ammonia in a high-temperature reaction with nitrogen, which is obtained from the air by low-temperature distillation. The synthesis of urea is another high-temperature, high-pressure reaction between the ammonia and carbon dioxide.

Another intermediate, useful in the synthesis of acrylic and methacrylic monomers, is hydrogen cyanide. Most of this is now being produced either directly from methane or indirectly via synthesis gas and ammonia. In the first instance, methane and ammonia are reacted together with oxygen of the air and in the presence of a platinum catalyst at high temperatures to form hydrogen cyanide and water. In the indirect process, methanol is first formed from the synthesis gas, and then further reacted with the carbon monoxide of the synthesis gas to form methyl formate. The latter is then reacted with ammonia to obtain formamide which in turn readily decomposes to hydrogen cyanide and water. Although much more involved, the indirect process gives higher yields and less purification is required.

Chemicals from higher paraffinic hydrocarbons

The higher gaseous saturated hydrocarbons of propane, butane, and pentane are finding applications similar to methane for the production of a variety of aliphatic chemicals which are useful in the synthesis and compounding of plastics. A good example is the catalytic air oxidation of propane and butane which yields a mixture of oxygenated compounds consisting of formaldehyde, acetic acid, propyl alcohol, acetone, propionic acid, butyraldehyde, and other compounds which are similar.

Chemicals from aromatic hydrocarbons

Before World War II, the only source of aromatic hydrocarbons was coal tar, a byproduct of the coking ovens. The coal tar was separated, by complicated processes, into many of its constituents but none of these was obtainable in a high state of purity. Nowadays, a great share of the aromatic hydrocarbons are obtainable from petroleum through refinery processes involving cracking, reforming, alkylation, cyclization, and dehydrogenation. Benzene, toluene, and similar common aromatics of high purity are, therefore, obtained. Also obtained are the newer alkylated benzenes.

Intermediates from benzene: For many years, benzene has been basic to a host of aromatic chemicals, many of which are important intermediates for plastics. Phenol, styrene, aniline, adipic acid, and maleic anhydride, all of which find use in the synthesis of high polymers, are a few examples.

No doubt phenol is the most important of the benzene derivative; over 300 million lb. are produced annually in this country. There are three main processes for the conversion of benzene to phenol, which involve three separate intermediates. The older and more common of these is the B.S.A. (benzene sulfonic acid) process involving the sulfonation of benzene and subsequent caustic hydrolysis of the sulfonic acid to phenol. The second process utilizes chlorobenzene as the intermediate, which is formed by the chlorination of benzene. This in turn is hydrolyzed to yield phenol. The third process was mentioned earlier in the discussion of chemicals from propylene. This process involves cumene (isopropylbenzene) as the intermediate. Upon oxidation and simultaneous hydrolysis, the cumene is converted to phenol and acetone.

Styrene, included in the earlier discussion of ethylene derivatives, is formed by first alkylating benzene with ethylene and then dehydrogenating the ethyl benzene to produce styrene. Aniline does not find much use in the aniline-formaldehyde resins, but is useful in the synthesis of dyestuffs, antioxidants, and stabilizers. All of these products are, of course, essential in the compounding of plastics.

Adipic acid, one of the nylon intermediates, is made from cyclohexane, obtained either directly from petroleum products or by hydrogenation of benzene. The latter source is preferred by one of the larger nylon producers. Adipic acid is produced by a three-stage oxidation of cyclohexane: first to cyclohexanol, then to cyclohexanone, and finally to adipic acid. The present process involves air oxidation in both liquid and vapor phases and is quite complex and difficult to control.

Maleic anhydride, which is finding increasing use in the production of maleate polyester resins, is produced by the air oxidation of benzene. This process, unlike the air oxidation of cyclohexane, succeeds in rupturing the ring and producing an unsaturated dibasic acid directly. The anhydride is recovered from the oxidation products by adsorption in a mineral oil solvent, thus preventing its hydration and possible inversion to isomeric fumaric acid.

Intermediates from toluene and xylene: These materials are similar to benzene and represent the methyl homologs of the benzene derivatives. However, the presence of another substituent on the benzene ring gives rise to isomeric products, some of which are difficult to separate. In place of phenol, the cresols, both para and ortho, are formed by either sulfonation or chlorination of toluene and subsequent hydrolysis of the intermediate. Methyl styrene is now being produced by first reacting toluene with ethylene to form ditolyl ethane. This product, in turn, is decomposed at high temperatures, resulting in the formation of methyl styrene and toluene.

Xylenols are synthesized from xylene in a manner similar to the production of phenol via the sulfonic acids or chloroxylenes. The most important use for xylenes today, however, is in their conversion to the corresponding phthalic acids by air oxidation. Ortho-xylene, now obtainable from petroleum sources in high quality and at reasonable prices, is competing with naphthalene for the production of phthalic anhydride. Meta-xylene in a similar reaction yields isophthalic acid, and para-xylene gives the terephthalic acid. These latter phthalic acids are finding use in the polyphthalate-glycol ester resins, such as Dacron fiber and Mylar film. (See Fibers Chart, p. 554 and Films Chart, p. 532.)

Intermediates from naphthalene: Naphthalene, obtained chiefly from coal tar, is one of the larger and more easily separable of the coal-tar constituents. Two main products derived from naphthalene are beta-naphthol and phthalic anhydride. The production of beta-naphthol (similar to the B.S.A. phenol process described above) involves the selective sulfonation of naphthalene with oleum or concentrated sulfuric acid and subsequent alkali hydrolysis by high-temperature fusion to form the naphthol. This intermediate finds uses in dyestuffs, which in turn are used as colorants in plastics. The conversion of naphthalene to phthalic anhydride is the same type of vapor phase catalytic air-oxida-

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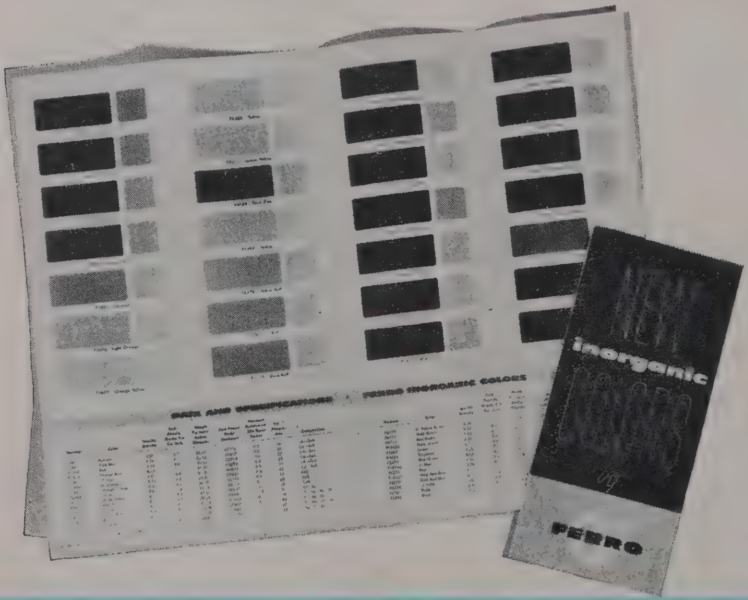

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tion process as described for phthalic from ortho-xylene. Maleic anhydride is formed as a concomitant product with phthalic anhydride.

Cellulose and furfural

For a discussion of cellulose as a raw material for plastics, see p. 93; for a discussion of furfural as a basis for the production of furane resins, see p. 119.

Over one-half of the total production of furfural finds use as a chemical intermediate for the manufacture of hexamethylenediamine which is one of the starting materials for making nylon. Furfural is first decarbonylated to form the parent hydrocarbon, furan, and this in turn is hydrogenated to tetrahydrofuran. It is then reacted with hydrogen chloride to open up the furan ring and form the 1,4 dichlorobutane. Upon cyanation of the latter with KCN, adiponitrile is formed and this is finally hydrogenated to the hexamethylenediamine.

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Consult the Subject Index for additional information concerning chemicals for plastics. For sources, see Directory Index, p. 1078.

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Colorants for plastics

By James E. Simpson* and Douglas P. Brush†

One of the chief attractions of plastics materials is that they can be colored to nearly any hue. Yet the practical art of coloring plastics is one of the more misunderstood aspects of the industry, perhaps because the subject seems tremendously complex to the inexperienced.

This is true to a certain extent. Final details are best left to the professional, who has the necessary knowledge of color theory, colorant properties, and plastics engineering. Nevertheless, the fundamentals of color and colorants are simple enough to be understood by the average person working with the design, molding, or fabrication of plastics articles.

To understand any coloring operation, one should have a fairly clear idea of what is meant by such terms as "color," "colorant," "hue," "saturation," "value," "shade," and so on (1).[1]

First of all, it must be realized that *color* is not a substance but an *effect*. It exists solely in the brain of the beholder. The eye translates light wave impulses into nerve impulses and transmits them to the brain where they register as red, blue, green, etc.

A *colorant* is any physical substance which modifies light waves striking it by absorbing some and reflecting others, thereby changing their energy composition. It is this altered light that produces the effect called *color*.

Visible light is only a small part of the vast spectrum of electromagnetic radiation which includes radio waves, infra-red, ultra-violet, X-rays, gamma radiation, and cosmic rays. Ranging in wavelength from approximately 400 (deep violet) to 700 (deep red) millimicrons, this narrow band represents approximately one octave on a keyboard of more than 40 octaves. In this comparatively small span lies the rainbow and its three primary colors—red, yellow, and blue. From these, with the addition or subtraction of white, gray, or black, theoretically more than 7,000,000 individual colors can be created.

Any of these colors can be described in terms of the three qualities of the Munsell system: 1) *Hue*—an indication of wavelength: red, yellow, green, etc. 2) *Value*—sometimes called *reflectance* or *brightness:* the position along the achromatic scale ranging from white to black. *Shade, tone,* and *tint* are three areas on this scale. 3) *Chroma*—also called *strength, saturation,* or *purity.* Relationship of these qualities is shown in Fig. 1, below.

While these qualities serve to describe a color, its perception is often influenced by several other factors such as transparency, texture, size, and angle of viewing. All of these factors together are considered by the professional color stylist when it comes to solving practical problems of originating or matching colors.

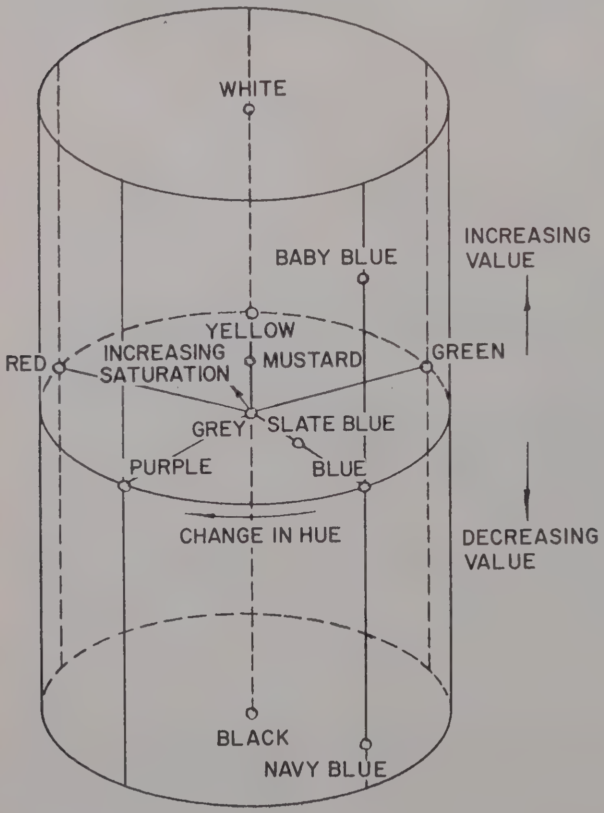

FIG. 1: Relationship of the three color qualities of the Munsell system. "Hue" changes around the periphery of the center circle; "value" increases or decreases vertically from the center circle; "chroma" or saturation increases from the center dot outward.

Color matching

While color theory is a branch of the physical sciences, the general approach to the matching or creating of colors lies more in the field of the artist than of the scientist. Actually, the ultimate objective in producing a color is to have it viewed by the human eye; accordingly, it should be the human eye which has the last word in judging a color. Here, perhaps, is where the eye and color measuring instruments come to the parting of the ways. The human eye is not linear in its perception of color. That is, it is not as sensitive to the colors at the

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*Color Div., Ferro Corp., 4150 E. 56th St., Cleveland 5, Ohio. †Ferro Corp.
Recent Developments and References were prepared by the editors.

[1] Numbers in parentheses link to References, p. 328.

extremes of the spectrum as it is to those in the middle. A machine tends to measure all hues equally. While people may vary in their ability to perceive color and detect small color differences, visual judgment in general is faster, cheaper, and usually just as accurate as any machine or combination of machines.

A device commonly used for color matching is the color matching booth. It consists of nothing more than a curtained booth with two separate overhead light sources. One is a standard incandescent and the other is a standardized fluorescent which is spectrally as near as possible to northern daylight. By means of a switch the operator may change from one light to the other, thereby detecting any shift in closeness of match between two color samples being compared under the different light sources. It is this shift that gives colorists their biggest headaches, and is one of the major considerations in the supplying of colorants for plastics.

It is relatively simple for even an inexperienced colorist to produce a color match under a single light source. The real trick is to get two samples to match under two or more different light sources. When two materials are the same color under one light source and different under another, they are *metameres.* A match under one light source with no guarantee of a match under other light sources is a *metameric match,* and the shift in colors between similar samples is a *metameric shift.* When two colors are the same under any light, they are a *spectral match* (2).

The only way to get a perfect spectral match is by using exactly the same pigments or dyes. Since light waves are reflected in accordance with the basic atomic and molecular structure of a material, any deviation in these areas will produce a corresponding deviation in the color. Different materials or pigments may absorb and reflect the same light waves under one light source but they can never be exactly the same under all light sources. In some cases, the differences can be extreme.

Therefore, a plastics colorist usually tries to produce a resin color from the same pigments as those in the sample. The problem becomes complicated when he has to match colors in two or more different types of resins.

Different resins often require different pigment formulations (Table I, p. 324) because of varying colors in their uncolored state. Also, certain pigments cannot be used in certain resins because of chemical interaction. Color matching between

pments...Recent Developments...Rece

A highly pigmented paste dispersion (*Scotch Master Paste,* Plastic Molders Supply Co., Inc.) has a polyester resin vehicle which is free of styrene monomer . . . is compatible with all resins and is designed not to alter cure time.

A very red-shade phthalocyanine blue pigment (*Cyan Blue XR-55-3770,* Pigments Div., American Cyanamid Co.) has color stability at elevated temperatures . . . is an all-purpose pigment and is crystal-stable in the aromatic solvents and plasticizers generally used by the plastics industry.

Twenty-seven colorants (*Floral Line,* H. Kohnstamm & Co., Inc.) for dry blending with polyethylene are currently being used in the manufacture of artificial flowers.

A new line of color speckles (Color Div., Ferro Corp.), for achieving special "salt-and-pepper" color effects in styrene, polyethylene, acrylic, and polyester resins, may be used alone or with regular pigments in either opaque or translucent resins. A line of "purified pigments" has also been developed for use in coloring fluorine resins . . . are manufactured at temperatures higher than the 650° F. at which the fluorine resins are processed and are, therefore, especially stable and nonreactive.

Plastics parts can now be dyed in any color and in quantities from "one part to a million" (Colorite Industrial Dyers) . . . nylon, polystyrene blends, polyesters, polycarbonate, acetal, and polypropylene parts have been successfully dyed without affecting tolerances.

Finely powdered aluminum (Silberline Mfg. Co.), in plasticizer or mineral oil dispersions, is available in a 160-mesh grade (*Silvex 1000*), a 325-mesh grade (*Silvex 2000*), and a 325-mesh grade with greater coverage and hiding power (*Silvex 3000*). The plasticizer-dispersed products are used for vinyl calendering and extrusion, while the mineral oil pastes are used for molding materials . . . by using transparent or opaque dyes, it is possible to achieve metallic colors.

A synthetic pearling agent (*Perlex 100,* Rhodia, Inc.), for incorporation before extruding or molding polyvinyl chloride, cellulose acetate, and polyethylene, is stabilized against light exposure and is nontoxic . . . may also be used in surface coatings.

New metallic colorants (*Auravin,* Interchemical Corp. Finishes Div.) for vinyl sheeting and coated fabric dry with the same speed as conventional vinyl inks and should be handled in the same manner. Clear topcoats increase the abrasion resistance and impart increased depth to the colors on heavy gage sheeting and coated fabrics.

plastics and non-plastics materials is even more of a problem.

If absolutely pure colorants were available to the plastics industry, the problem of producing exact colors would be greatly simplified. Theoretically, only four pure pigments—blue, green, yellow and red—should be needed. However, every available pigment is actually two colors—a primary top tone and a secondary undertone. Sometimes the undertone lies at the other end of the spectrum from the primary color. For example, the undertone of dark Cadmium Red is a blue. These undertones often cause difficulties in color matching. Certain greens have undertones of blue or yellow. Some yellows have undertones of green or red. If Ultramarine Blue (undertone red) is mixed with Chrome Yellow (undertone red), a dirty color would result since the green produced would be partially neutralized by the complementary red undertones. (Complementary colorants *subtract* from the amount of energy each would normally reflect, producing mixtures tending towards dark gray or black. Conversely, when complementary colored lights are mixed, the result tends toward white light.) (3)

The expert colorist, then, not only has a keen, well-trained eye, but he knows his pigments thoroughly as well, for the matching of plastics colors, even with the aid of machines, is generally a hit-or-miss process. The more expert the matcher, the more hits and less misses, and the fewer pigments and dyes needed. While many plants producing colorants for plastics have on file color chips and formulations for more than 15,000 individual colors, usually less than 50 basic colorants are needed for their manufacture.

Generally a colorant supplier is requested "to match sample within commercial limits." Certain colorants are more expensive than others and sometimes it is too costly to produce the exact color requested. If an expensive colorant is needed to produce a desired color, and the customer is unwilling to pay the price, the colorist often is forced to substitute a slightly different and less

TABLE I: Processing conditions and suitable colorants for

Plastic	*Processing conditions and properties required*	*Suitable groups of coloring matters*
1. Phenol-formaldehyde molded laminates	Mildly alkaline reducing atmosphere Molding temperatures up to 170° C. Usually only moderate light fastness	Spirit and hydrocarbon soluble dyes Spirit soluble acid dyes Lakes and toners Organic pigments Inorganic pigments
2. Phenol-formaldehyde surface coatings and cast resins	Mildly acidic or mildly alkaline reducing atmospheres Long heating at moderate temperatures Better light fastness than for molded items	Spirit and hydrocarbon soluble dyes Spirit soluble acid dyes Phthalocyanines Lakes and toners Organic pigments Inorganic pigments
3. Urea and melamine-formaldehyde products	Mildly acidic reducing atmosphere for a short period Superlative light fastness	Selected water soluble dyes Inorganic pigments Vat dye pigments Phthalocyanine pigments Organic pigments, lakes, and toners
4. Casein products	Low mixing and extruding temperatures (approximately 100° C.) Acidic reducing conditions during formulation Moderate-good light fastness Must not bleed into the formulating solution	Water soluble acid and direct dyes Organic pigments, toners, and lakes Phthalocyanine pigments Inorganic pigments
5. Cellulose plastics (cellulose acetate, cellulose acetate butyrate, ethyl cellulose, etc.)	Substantially neutral to mildly acidic atmosphere Mixing time of the order of 15 min. at 180° C. Short light temperature of injection 180 to 200° C. Moderate-good light fastness	Spirit and hydrocarbon soluble dyes Organic pigments (except those prone to bloom) Lakes and toners Dispersed dyes Basic dyes
6. Polyvinyl chloride and copolymers	Tends to become acidic during processing High temperature compounding up to 170° C. for long periods Very good light fastness High degree of dispersibility	Selected spirit and hydrocarbon soluble Vat dye pigments Organic pigments Inorganic pigments (except those prone to bloom and migrate) Lakes and toners Phthalocyanine pigments
7. Fluorocarbons	High heat stability Resistant to acids and alkalies High degree of dispersibility (very fine)	Inorganic pigments Phthalocyanines and selected organic pigments
8. Polyethylene	Neutral inert processing conditions High temperature processing and extruding depending on grade Very good fastness to light	Organic pigments (except those prone to bloom and migrate) Lakes Vat dye pigments Phthalocyanine pigments Selected hydrocarbon soluble dyes

use with various commercial plastics

Plastic	Processing conditions and properties required	Suitable groups of coloring matters
9. High-density polyethylene	Neutral inert processing conditions Very high temperature processing conditions Very good light fastness and heat stability	Inorganic pigments Organic pigments Phthalocyanine pigments
10. Polymethyl methacrylate	Strongly oxidizing atmosphere during polymerization Moderate temperatures Very good light fastness	Selected hydrocarbon soluble dyes Selected vat dye and organic pigments Phthalocyanine pigments
11. Polyesters	Strongly oxidizing atmosphere during polymerization Very good light fastness High degree of dispersibility	Vat and other organic and inorganic pigments as flushed pastes Inorganic pigments Selected hydrocarbon soluble dyes as flushed pastes
12. Polyurethane foams	Inertness of colorant to catalytic effect and alkaline conditions Light fastness not of importance High degree of dispersibility	Water pulps and flushed pastes of inorganic and organic pigments Vat dye pigments Phthalocyanine pigments
13. Nylon	High heat stability Very good light fastness High degree of dispersibility Strong reducing action of nylon above 500° F.	Inorganic pigments Phthalocyanine pigments Selected anthraquinone pigments
14. Alkyds	Very good light fastness High degree of dispersibility Moderate temperature Bleed resistance	Selected vat dye and thioindigoid pigments Inorganic pigments Phthalocyanine pigments
15. Epoxies	Very good light fastness High dispersibility Moderately high temperature	Organic pigments Phthalocyanine pigments Inorganic pigments
16. Polystyrene	Processing conditions neutral but residual oxidizing catalyst may be present. High temperature processing and injection 200° C. and above; good to excellent light fastness; high degree of dispersibility	Hydrocarbon soluble dyes Organic pigments Lakes Phthalocyanine pigments Inorganic pigments
17. Polypropylene	Neutral inert processing conditions Very high temperature Very good light fastness and heat stability	Inorganic pigments Organic pigments Phthalocyanine pigments
18. Silicones	Neutral inert processing conditions Molding temperature 500° F. and above Excellent light fastness and heat stability	Inorganic pigments

expensive formulation. Sometimes there is a great price differential between two very close shades of the same color.

Types of colorants

Three basic families of colorants are available for coloring plastics: *dyes, organic pigments,* and *inorganic pigments.* Each has characteristics (Table II, p. 326) and properties which limit or facilitate their use in various resins.

Dyes are synthetic or natural organic chemicals that are soluble in most common solvents. Possessing very good color strength or purity, they are available in an extremely wide range of colors. They are transparent, have excellent brightness, and are characterized by low plasticizer absorption, low dielectric strength, low specific gravity, and often by high bulk in air. There are variations in the properties of individual dyes within the family, and this variation affects their suitability as colorants for some resins. The inherent disadvantages of dyes is their poor resistance to light and heat. In fact, they are completely excluded as colorants for certain resins because of high molding temperatures. Furthermore, they have a pronounced tendency to bleed—that is, migrate to the surface and rub off—particularly in such resins as polyethylene.

Organic pigments are divided into *toners* and *lakes.* Toners are of two types, *insoluble organic toners* and *lake toners.* The former are usually free from salt-forming groups. Lake toners are practically pure, water-insoluble heavy metal salts of dyes, minus the fillers or substrates of ordinary lakes. They are considerably more powerful than lakes, which are water-insoluble heavy metal salts or other complexes of dyes that have been precipitated upon or admixed with a base or filler, usually inorganic.

As a group, organic pigments are characterized by very limited solubility, low specific gravity, high bulking ratios, high oil and plasticizer absorption, and superior dielectric properties. Available in a very wide range of hues, they have good brightness, better transparency than the inorganics, and high coloring strength. They

TABLE II: Characteristics of basic colorants for plastics

Colorant	*Color*	*Heat stability*	*Light stability*	*Brightness*	*Transparency*	*Tinctorial power*	*Oxidation effect*
INORGANIC PIGMENTS							
Chrome Green	Green	Good	Good	Poor	Opaque	Weak	—
Ceramic Cobalt Blue	Blue	Excel.	Excel.	Fair	Opaque	Weak	—
Ultramarine Blue	Blue	Good	Good	Good	Transl.	Fair	—
Iron Oxide	Black-red-brown	Good	Good	Poor	Opaque	Weak	Inhibit
Chrome Yellow	Yellow	Fair	Good	Fair	Opaque	Fair	—
Molybdate Orange	Orange to scarlet	Fair	Poor	Fair	—	—	—
Mineral Violet	Violet	Fair	Fair	Fair	—	Weak	—
Cadmium	Yellow red	Excel.	Excel.	Fair	Opaque	Fair	None
Titanium Dioxide	White	Excel.	Excel.	Very good	Opaque	Good	None
Zinc Oxide	White	Good	Good	Very good	Opaque	Good	—
Antimony Tri-oxide	White	Good	Good	Moderate	Opaque	Fair	—
ORGANIC PIGMENTS							
Pthalocyanine Blue & Green	Blue & green	Good	Good	Very good	Transl.	Very good	Inhibit
Benzidine Hansa	Orange & yellow	Fair	Fair	Very good	Transp.	Very good	—
Lithol	Red	Fair	Fair	Good	Transl.	Good	—
BON	Red	Fair	Fair	Good	Transl.	Good	—
Toluidine & Para Red Toner	Red & orange	Fair	Fair	Good	Transl.	Good	—
Carbon Black	Black	Fair	Good	—	Opaque	Very good	Inhibit
ORGANIC DYES							
Nigrosine & Induline	Gloss black	Good	Good	—	Opaque	Very good	Inhibit
Acetate Dyes	Wide range	Fair	Fair	Good	Transp.	Very good	Inhibit
Acid Dyes	Wide range	Fair	Fair	Good	Transp.	Very good	—
Basic Dyes	Wide range	Fair	Poor	Excellent	Transp.	Very good	—
Sulfur Dyes	Wide range	Fair	Fair	Poor	Opaque	Good	—

are better than dyes in their resistance to heat and light, although decidedly inferior to the inorganics in this regard, and have less tendency to bleed since they are relatively insoluble. Naturally, individual organic pigments vary in their resistance properties and adaptability for coloring plastics. They are generally used in plastics for interior applications.

Inorganic pigments, generally metallic oxides, are calcined during processing at 1900 to 2400° F. Because of this they are much superior to the organics and dyes in weather resistance, heat- and light-stability, and resistance to bleeding. In addition, they are less of an antioxidant. They are characterized by high specific gravity, low oil and plasticizer absorption, good chemical resistance, and general opacity, although one or two pigments in the group are transparent. They disperse well even though they are somewhat coarse and hard in texture. In thin films they may appear specky. In strong concentrations, inorganic pigments produce bright colors, but they are weak tinctorially and their tints and pastels are often dull.

Because of the trend toward higher molding temperatures, there is an increasing need for light-fast, heat-resistant colorants. Existing resins are being pushed to higher temperatures and the newer resins such as polypropylene, ABS, fluorines, and silicones are all normally molded at somewhere from 400 to 700° F. As a result, many of the organic pigments and dyes are being eliminated from use in these resins.

A miscellaneous group of pigments are available for the production of "special effects" in finishing and decorating. Included in this group are metallic, pearlescent, fluorescent, and phosphorescent pigments, metallic flakes, and color speckles. Designed as "eye catchers," most of these pigments, with the possible exception of the fluorescent/phosphorescents, are proprietary items from individual colorant supply houses.

Colorant selection

Unfortunately, with plastics there is no simple choice of using one single pigment family or system over another, or whether or not to use an organic dye or an inorganic pigment to produce a given effect. In practice, it is just not possible to produce a desired color solely with one type of colorant. In almost all cases different colorants are blended, and frequently colorants from one family will be blended with colorants from another family. These must be evaluated properly because each has different properties in different media and every resin has its own individual color peculiarity.

First of all, the color and clarity of the resin are limiting factors. Almost all plastics have some natural color. Very few of them are clear and colorless. As an extreme example, a highly-filled polyester resin cannot possibly be produced with a translucent or transparent effect. In some of the polyester resins containing a high percentage of certain clay fillers, it is impossible to produce a high-reflectance white because of the lower reflectance of the clay fillers. Many plastics, particularly the alkaline phenolics, furanes, rubber compositions, and petroleum polymers have or develop strong self-colors during processing—usually yellows, browns, grays, and blacks. Furthermore, chemical interaction between the resin and the colorant may possibly have some effect upon the final color.

Sometimes supposedly clear stocks tend to develop yellowish casts and require the addition of blue colorants to produce greenish or achromatic grays. "Brightener" dyes (colorless compounds which produce bluish fluorescent color effects when exposed to ultraviolet light) can also be added. The purpose of these dyes is to increase the apparent "whiteness" of the resin.

The recoloring of scrap and reworked stocks is undoubtedly the most difficult self-color problem the colorist has to overcome. Each batch is different and each presents a different color-matching problem. Furthermore, it is usually necessary to adjust such properties of the batch as flow, flexibility and opacity. For example, large additions of pigments adversely affect flow because of their plasticizer absorption. Therefore, the addition of weakly colored or virgin stock is often necessary to increase flow and allow the addition of more pigments which may be necessary when lightening dark-hued stocks with white or light-gray. It should also be remembered that stocks containing fugitive colorants will tend to give fugitive final color effects. (4)

Another consideration is the pH of the resin itself and the pH conditions under which the end product will be used. These conditions must be considered when selecting colorants, since their stability may vary greatly with the pH and they may change in hue, solubility, fastness, and their effects on the properties of plastics. For example, a plastic article for use in the kitchen should have good alkali resistance and the colorant used in it should also be alkali-resistant. Likewise, a plastic article designed for use in a chemical laboratory should be resistant to both alkalies and acids, as should the colorants.

Oxidation-reduction conditions must also be considered when selecting colorants for plastics. For example, most organic colorants can be bleached (oxidized) and many other coloring agents can be reduced. In addition, some coloring agents are active antioxidants. In such cases, the colorist has to determine the degree to which they might inhibit the curing of the resin.

Reactions between colorants, catalysts, antioxidants, preservatives, fungicides, vulcanizates, and any other special additives must also be accounted for, particularly in closed molds where the mix is subjected to high heats and pressures.

Dispersion is still another factor which influences the proper selection of colorants. Some colorants, particularly the phthalocyanines, are more difficult to disperse than others. Therefore, in a given resin molding operation it is sometimes uneconomical to use certain colorants because of the amount of work which will have to go into mixing the resin and colorant before complete dispersion can be achieved.

And, finally, the method used to incorporate the colorant has to be considered. If a molder intends to dry-color polyethelene, for instance, it becomes necessary for him to use a pigment system that has been processed so as to improve the dispersion of the components. However, this is not necessarily true for the resin manufacturer or the custom compounder, because they use mixing equipment which performs much more work on the colorant-resin mix than it receives merely from its passage through the cylinder of an injection molding machine. The development of a new type Venturi breaker plate for injection molding machines has considerably aided the molder in achieving better dispersion in the high-melt index, low- and high-density polyethylenes, and in high-melt index, high-density polypropylene. (5)

Coloring methods

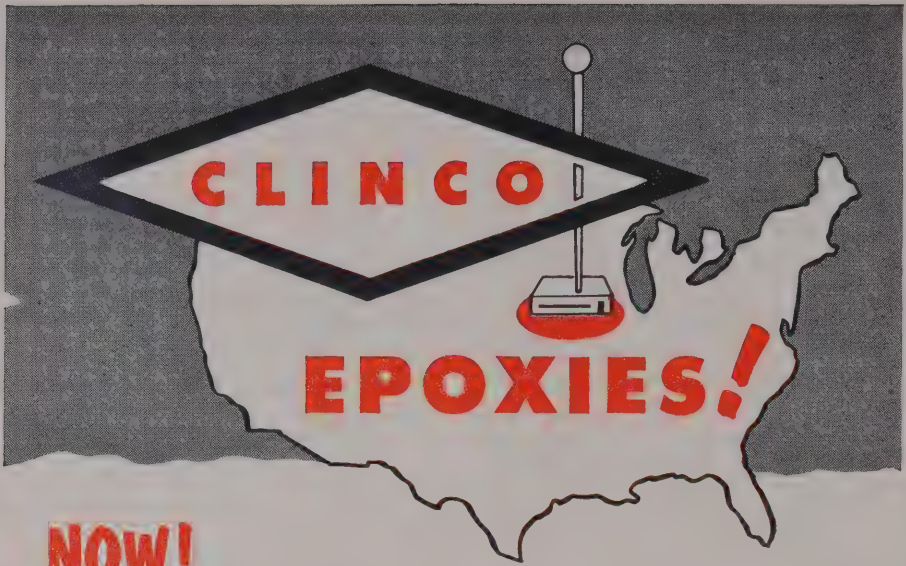
Colorants can be added to most resins at any one of three stages in their travel from the basic manufacturer to the consumer of the molded part: 1) the resin manufacturer can add the colorant before the resin leaves his plant; 2) the molder of the finished part can add the colorant himself; or 3) the colorant and resin mix can be prepared by a resin compounder.

At exactly what point the colorant is introduced into the resin is determined by economy, variations in markets and service, and differences in resin properties. Because of inventory problems and warehouse space, a considerable number of large custom molders prefer to color the resin themselves. Other molders who do not turn out a variety of molded objects and steadily run a small number of colors naturally prefer to buy resin which is precolored. (6)

The most common way for molders to color thermoplastics is by dry coloring. This operation consists of first tumbling a powdered pigment and the resin granules together, and then passing the mix through the molding machine.

Since it is virtually impossible to supply precolored liquid epoxy or polyester resins because of the adverse affect of colorants on their shelf-life, these materials are almost always colored by the molder with paste color concentrates. These paste concentrates are nothing more than compatible liquid vehicles or carriers into which colorants have been thoroughly dispersed. They are merely added to the liquid resin and good dispersion is then obtained through a simple stirring operation.

Paste colors are not the answer for all polyester applications. Molders who are doing hand lay-up operations at room temperatures and do not want to be forced to mix colors, use colored gel coats. Gel coats are also used where it is desired to keep the



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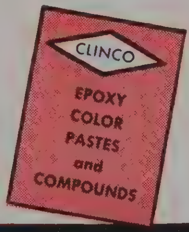

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Surface versus integral colors

Broadly speaking, plastics coloring methods can be divided into two categories; those in which the colorant is applied to the surface of the molded part, and those in which the colorant is dispersed throughout the article. Obviously, the former must follow the molding operation, while the latter must take place prior to molding.

There are advantages and disadvantages to both surface coloring and integral coloring. For example, a surface-colored article permits the use of discolored resins and other materials such as reinforcing fibers without sacrificing appearance. Where opacity is not required, striking "depth" effects can be achieved by using transparent colorants and clear resin. Since the layer of colored resin is very thin and only on the surface, less total colorant is used than in the case of the article which is colored throughout. On the other hand, abrasion of the integrally colored part will not result in areas from which color has been worn away (7).

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Stabilizers

By Gerry P. Mack*

pments...Recent Developments...Recen

Epoxidized plasticizing stabilizer produced from pure soybean oil (*Epoxy Gen 80* and *Epoxy Gen 90*, General Mills, Inc.) is claimed to give up to 10% higher epoxy content in the finished product than usual epoxidized oils . . . has up to 50% less impurities and up to 50% less viscosity.

Rigid vinyl sheeting, tubing, and pipe can now be formulated with a new organo-tin stabilizer (*T-360*, Advance Solvents & Chemical Div. of Carlisle Chemical) . . . imparts long term heat stability, excellent light stability, improved heat distortion characteristics. High molecular weight PVC resins with T-360 show sag temperatures about 10° F. higher than similar compounds containing conventional tin mercaptide stabilizers.

A new stabilizer (*Ferro 763*, Ferro Chemical Corp.), for use in polyvinyl chloride food packaging, has been approved by the U.S. Food and Drug Administration . . . may be used at operating temperatures of 365 to 385° F. . . . is recommended for calendering, extrusions, and plastisols.

Modified dibutyltin maleate stabilizer (*RS-27*, Metal & Thermit Corp.) is easily handled . . . has excellent solubility in solvents, plasticizers, plastisols, and organosols . . . particularly useful in plastisols for slush molding . . . eliminates plate out.

Ultra-violet light-absorbing chemical (*UV 314*, American Cyanamid Co.) is expected to be available early next year . . . will be used initially in polyethylene fibers, film and sheeting . . . expected to have important impact on polyethylene as well as polypropylene markets.

Many of the polymers now being used as plastics materials must be stabilized against the effects of heat, light, and weather before they can be processed properly. In most cases, heat is used to work up these polymers for commercial applications and the finished plastic product must often be able to withstand the rigors of weathering, particularly sunlight.

When a vinyl chloride polymer is subjected to heat or light, the following degradation reactions occur:

Heat degradation: During heat degradation, there are probably two main mechanisms involved:

1) The loss of hydrogen chloride through a "zipper-type" reaction (see Fig. 1, p. 334), resulting in polymer unsaturation. This is responsible for the conjugated double bond structures which result in color formation. When a vinyl polymer is exposed to high temperatures, color changes from pink to yellow to brown, and finally to black, indicating a completely degraded resin.

2) The simultaneous oxidation of these polyene systems, probably to carbonyl groups.

Reactions 1 and 2 compete in the presence of oxygen and are both in operation whether the degrading influence is heat or light. Evidence indicates that heat and/or light seem to merely change the relative rates of HCl formation and oxidation.

The initial heat stability of vinyls is also affected by any catalyst residues which may be left in the resin. Such impurities can weaken the polymer change so that during the heat degradation process, the rate of dehydrochlorination increases considerably.

Light degradation: When vinyl polymers are exposed to light, oxidation leading to chain scission and cross-linkage seems to be the main cause of breakdown. Loss in tensile strength is due principally to the chain scission; cross-linkage causes severe embrittlement and affects the compatibility of the plasticizers with the vinyl polymer. In many cases, this is why plasticizers sweat out. Cross-linkages on exposure to light can occur rapidly when plasticizers with branch chain alcohols (e.g., diisooctyl phthalate) are used. It has become common practice to stabilize such plasticizers with an antioxidant to prevent this type of embrittlement.

It is thus apparent that light stabilizers will not necessarily be good heat stabilizers and vice versa. As far as light stabilization is concerned, at the present time, there seems to be a trend toward the use of ultra-violet absorbers to screen out certain wavelengths that cause the degradation. (For a discussion of ultra-violet absorbers, see p. 372.)

Antioxidants, particularly complex phosphorus compounds, as well as epoxy-type compounds and/or plasticizers, when used in proper ratio with suitable barium-cadmium systems, also improve light stability. One class of stabilizers which not only has excellent heat stability but, in most cases, exceptional light stability as well, are the organotin compounds.

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* Director, M&T Laboratories, Inc., 1 Union St., Carteret, N. J., Product Mgr., Organic Chemicals, M&T Corp., 100 Park Ave., New York, N. Y.

Recent Developments were prepared by the editors.

It must be emphasized that the final light stability of any vinyl compound will also depend greatly on the past heat history of the compound. If it has not been properly heat stabilized, then certain degradation reactions that have occurred will make the finished compound more sensitive to light by the presence of weakened points in the molecular chain.

Mechanism of stabilization

Considerable work has been published on the action of stabilizers. It has been proposed (1)[1] that metallic stabilizers act as oxidation catalysts and prevent color degradation by disrupting chromophoric polyene systems by oxidation. The older and conventional theory has been that stabilizers act strictly by removing free hydrogen chloride. More modern theories lean toward a free radical mechanism. Winkler (2) offers the free radical mechanism to explain the observed results which occur during degradation and suggests the same would apply to the action of stabilizers. Definite evidence that polyvinyl chloride stabilizers can disrupt radical chain processes can be found in the work of Kenyon (3), who used a C-14 butyl-labeled dibutyltin diacetate. Based on his experimental results, Kenyon proposed the following mechanisms as a possible explanation:

$$R\cdot + (C_4H_9)_2\,Sn(OAc)_2 \rightarrow RC_4H_9 + C_4H_9Sn(OAc)_2$$

The butyl group reacts with the polymer radical R· formed by a previous extraction of a hydrogen atom from the vinyl polymer. The butyl group can then add to the polymer chain, blocking further cross-linking and oxidation at this one particular point.

Research done by the writer indicates that there is little doubt that in the case of some organotin stabilizers a free radical mechanism is the main action of such stabilizers. Results indicate that the dibutyltin group is the one that is most active as far as disrupting the free radical process that goes on during degradation. However, this is not the complete answer since, in some cases, the stabilizer contains active groups which can disrupt a radical chain process. Presumably such stabilizers perform a dual action by direct addition to the unsaturated polymer chain; on exhaustion of these radical terminating groups, the radical chain process can then continue. Evidence seems to indicate that cadmium type stabilizers also can function in this fashion but are much weaker in disrupting radical chain processes, and, furthermore, that zinc stabilizers appear to be weakest in this ability.

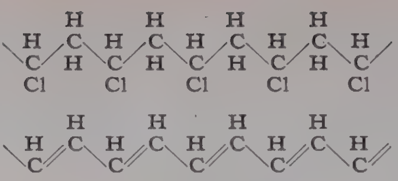

FIG. 1: On heating the polyvinyl chloride resin, rapid loss of hydrogen chloride occurs through a "zipper" reaction. HCl thus released acts as a catalyst in causing loss of more HCl

Further evidence in support of this theory can be seen in the greatly increased use of stabilizers which have antioxidant properties and are able to disrupt the radical chain processes.

As discussed above, the complexity of the reactions in the thermal and light accelerated decomposition of PVC polymers cannot be explained by one single mechanism; it seems likely, however, that the free radical mechanism may turn out to be the more dominant one.

Lead stabilizers

The first stabilizers used in vinyl resins were based on lead, and they are still especially useful for electrical applications. The lead salts provide long term stability and are relatively inexpensive, but they have many drawbacks. Among these are their toxicity and high gravity which makes them expensive to use whenever volume costs are considered. Another very serious objection is their cross-staining, especially in any atmosphere containing sulfur.

The varieties run from litharge to dibasic lead phosphite. Other lead compounds such as lead stearate and dibasic lead stearate are fair heat stabilizers and have good lubricating properties. In general, most of the lead stabilizers give opaque compounds.

Organotin stabilizers

Early in the history of PVC technology, the organotin stabilizers with their multiple performance characteristics played an important part. Their initial use was for clear materials and they still maintain the distinction of being the only group of stabilizers which will give optical clarity in all types of PVC resins. They are good as heat stabilizers, depending on the types used, and also are outstanding as light stabilizers.

All commercial organotin stabilizers are based on a dibutyltin-R_2 where R is usually an acid, alcoholate, mercapto group, or some modification of these. The types of organotin stabilizers and their chemistry have been reviewed (4). The most important groups are:

Dibutyltin dilaurate was one of the first organotin stabilizers, and has been used on a large scale. It is very useful, especially for low temperature processing where clear compounds are desired. It functions not only as a heat and light stabilizer but also has excellent lubricating properties and is particularly suitable for calendering and extrusion of clear vinyls.

Dibutyltin maleate was synthesized to give better heat stability than the dilaurate, as well as light stability. The presence of the maleic group gives the stabilizer dienophilism. This enables it to react with the polyene structures which are formed during the degradation of PVC; by interrupting these structures through the typical Diels-Alder reaction, excellent retention of color of the PVC resin can be maintained even when high temperatures are used during processing. In most cases, this stabilizer is used in conjunction with the dibutyltin dilaurate since, by itself, it does not have any lubricating properties and will cause sticking on steel surfaces.

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[1] Numbers in parentheses link to references listed on p. 339.

A new stabilizer has been formulated to incorporate the lubricating properties of the laurate radical with the heat stability of the maleate in one molecular structure (5).

By means of further modifications through the electro-negative group, a series of all-purpose tin stabilizers have been developed which can be used for calendering, extrusion, plastisols, organosols, and so forth. With these, optical clarity can be obtained in flexible or rigid PVC. An outstanding property of these stabilizers is that they will not pick up moisture, and have very low extractability. They have excellent solubility in plasticizers and solvents, and are particularly useful for plastisols and organosols.

The dibutyltin thio stabilizers are the most powerful group of organic stabilizers known at present. These materials have the -Sn-S linkage and two main types are on the market—dibutyltin mercaptide and dibutyltin mercapto acetate ester. These compounds differ chiefly in their performance on heat stability. The latter is the better one, but it has no lubricating action; the former has a long chain hydrocarbon in the molecule which gives excellent heat stability with good lubrication and can be used by itself in many rigid applications. A combination of equal parts of these two and of PVC resin is general practice in rigid PVC compounds.

Recently, a new modified thio tin stabilizer (6) has been placed on the market, especially designed for rotationally cast vinyl plastisols; it is not as good in plastisols which are cured with a surface exposed to air. It is modified with a cadmium stabilizer plus an organic phosphite, does not cross-stain, and gives outstanding heat stability at low cost, even at the high temperatures used in rotational casting.

Dioctyltin compounds have been claimed to be nontoxic and there has been considerable interest in such stabilizers for PVC compositions, particularly film, which will come in contact with food. Investigations (7) have discussed the toxicity of the organotin compounds. The conclusions are that the dioctyltin compounds are apparently nontoxic by mouth or when applied to the skin (8).

Experimentally, the dioctyltin compounds show somewhat lower heat stability action with PVC than the dibutyltin compounds. A recent paper (9) showed heat tests.

Vinyltin compounds announced during the past year are a completely new group of stabilizers which have many interesting physical and chemical properties (10). Series of divinyltin compounds homologous to the dialkyl compounds mentioned above indicate that the vinyl group does not have the stabilizing action of the butyl group. However, various patents have been applied for on the use of these vinyltin compounds for copolymerization with vinyl chloride monomers to give a PVC copolymer with the properties of a prestabilized resin. The use of 2 to 3% of certain of these vinyltin compounds, homologous to the tin stabilizers above, will give copolymers that have heat stability superior to the alkyl tin compounds added after polymerization.

Barium-cadmium

These stabilizers comprise an important proprietary class of many mixtures, which can be divided into two basic groups:

Barium-cadmium solid type: This group is a combination of barium and cadmium laurate which is coprecipitated during manufacture. It is claimed that better heat stability is obtained by coprecipitation than if the two are used separately. Such stabilizers were very popular up to a few years ago; the main objection to barium-cadmium soaps is the fact that they "plate out" on the calender rolls and films formulated with them do not heat-seal well, particularly after aging.

They still are the workhorse in the barium-cadmium field, however, and have been modified with phosphites and polyhydroxy compounds for special purposes. The main drawback of "plate out" has not yet been overcome.

Liquid barium-cadmium systems are based on a barium phenate, usually in combination with a cadmium soap such as octoate or other suitable acids, plus an organic phosphite additive. They have cut down on calender "plate out" and in some cases have completely eliminated this objectionable property; they still must be used with care, however, particularly in clear films. The phenates are more compatible than barium-cadmium soaps and have improved heat-sealing and printing properties. They are particularly useful with sensitive pigments such as the lithol rubine reds, and overcome the color shifting during processing that occurs with the barium-cadmium soaps.

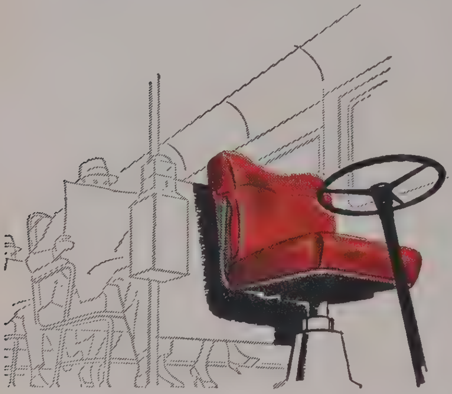
A new type of barium-cadmium liquid stabilizer (11) is based on a complete aromatic structure and is free of any "plate out" tendencies. When used as recommended, it gives vinyl films of optical clarity. This stabilizer system not only gives the outstanding heat stability associated with the phenate groups but also gives excellent light stability; it has advantages over the usual phenates since it is less volatile at high temperatures.

Zinc stabilizers

These stabilizers are usually zinc soaps of fatty acids such as laurate but in many cases are synthetic fatty acids such as the octoates. Because both zinc and cadmium are in the same group in the periodic table, early attempts were made to replace the cadmium-type stabilizers with zinc stabilizers. It was soon established, however, that zinc alone will rapidly turn black in a vinyl compound. Zinc stabilizers, therefore, are generally used with barium-cadmium stabilizers (powder or liquid); for best results high amount of phosphites and epoxies must be used. The combination of zinc stabilizers with barium-cadmium stabilizers also serves to prevent the sulfur staining that occurs when barium-cadmium is used alone.

Small amounts of zinc with barium-cadmium stabilizers and high ratios of phosphites further have a definite advantage in im-

Grueling use-test pits monomeric vs. polymeric plasticizers



Some years ago a vinyl upholstery manufacturer decided to field-test new materials for truck and transportation upholstery using a wide variety of monomeric and polymeric plasticizers, including Plastolein 9720. To compare *permanence* and *durability,* the different materials were installed on city bus drivers' seats.

After a time, all the upholstery containing monomeric plasticizers had failed. But all those made with polymerics, including Plastolein 9720, were still in excellent shape. So, the manufacturer concluded that only a *polymeric* plasticizer would meet its standards for transportation upholstery. And Plastolein 9720 was chosen on the basis that it was the *lowest cost of all the fine polymerics tested.*

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proving the initial color stability of the polyvinyl chloride compounds being formulated.

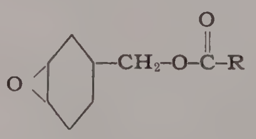
Organic stabilizers

Polyvinyl-chloride stabilizers based on pure organic compounds are not sufficiently powerful to be used by themselves, particularly for heat stability. Several classes are being used for synergistic action with metallic stabilizers; the organic compounds will give improved heat and light stability when used in proper ratios.

Organic epoxies are used in two types: epoxidized oils and esters, and chemical types based on condensation products of epichlorohydrin and bisphenol. The latter are expensive and have limited compatibility in PVC compounds. They have therefore been replaced by other epoxy plasticizers which have become a standard part of PVC formulations. These materials can function through the ability of the epoxy group to absorb hydrogen chloride, although the action is probably more complex than this simple description might lead one to believe.

The epoxy glyceride type plasticizers must be used cautiously, particularly if unsaturated type plasticizers are used in the same compound; an excessive amount can cause sweat out and tackiness, particularly on exposure to sunlight.

A new group of epoxy plasticizers which can also function as stabilizers has recently been announced (12). They are derivatives of cyclohexene oxide and can be classified as chemical epoxies. These compounds are unique in that the epoxy group is on the aromatic segment of the molecule; this makes it an effective solvating group for vinyl chloride resins. Structurally this group of compounds can be represented as:



ester of 3,4-epoxycyclohexylmethanol

Results on 3,4-epoxycyclohexylmethyl ester have been reported (13).

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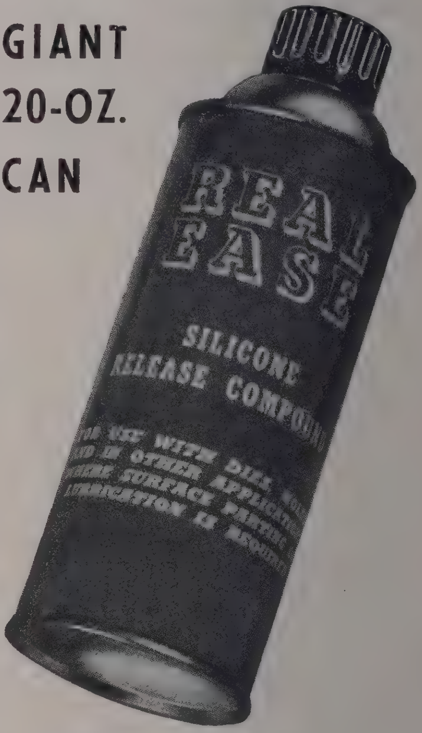

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Another important group of organic stabilizers are the *phosphites,* which are used mostly in combination with barium-cadmium and/or zinc compounds. Phosphites have a powerful synergistic action, and one part can replace up to one part of a cadmium stabilizer to give up to twice the heat stability and better clarity. Phosphites have long been recognized for stabilization purposes and are used extensively in lubricating oils as antioxidants. It is presumed that the phosphite stabilizers actually perform a similar function in PVC compounds by exercising antioxidant action during processing, and preventing degradation associated with the opening up of double bond formations. Phosphite compounds are also known as chelators, the theory being that they will chelate the metallic halides formed during the decomposition of the vinyl. Several high-boiling-point phosphites are being offered as auxiliary type stabilizers, particularly for use in clear film or where "plate out" is a problem.

The last group of purely organic compounds useful in stabilization are the *ultra-violet light absorbers.* Their particular use is to improve light stability over and above that obtained by the stabilizers mentioned above. They function by absorbing UV and dissipating its energy in such a way that it can no longer promote degradation. Benzophenones have been found to be the most satisfactory, and among them the 2-hydroxybenzophenones are of primary interest. The position of the hydroxyl group in the benzophenone series has a tremendous effect on UV absorption and, therefore, on actual light stability of PVC compounds. Their high cost prohibits general use but for specialized purposes small amounts on the order of 0.2% can be used successfully. The effect of UV light absorbers with other stabilizers has been presented (14).

Nontoxic stabilizers

Usually based on combinations of calcium and zinc soaps, several proprietary mixtures are on the market and have been approved

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by the U. S. Food and Drug Administration. For maximum stabilizing action, they must be used with high ratios of approved nontoxic epoxy compounds.

Chlorinated rubber

Stabilizers similar to those used for PVC are required for chlorinated rubber; they are usually of a type which can react very rapidly with hydrochloric acid, one of the primary breakdown products. Further, they must react with the unsaturation that may develop on exposure to heat and light, and preferably act as an antioxidant. Finally, good light stability must be obtained through the utilization of ultraviolet stabilizers or other compounds.

Since epoxy stabilizers are effective for absorbing HCl they are also effective in imparting heat and light stability to chlorinated rubbers. The chemical type epoxies are most useful, although the glycerides and epoxy esters can be used. For outdoor exposure, stabilizers that afford good color stability are barium-cadmium laurates and lead compounds used in combination with epoxides.

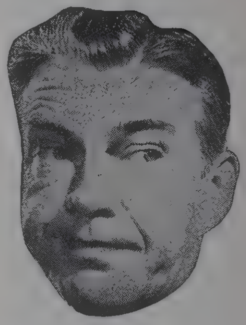
Polyvinylidene chloride polymers

Although at first glance it would seem that stabilizers for polyvinylidene chloride polymers would be the same as those used in PVC stabilization, there is actually no relation in the response of the two materials to stabilizers (15). Useful compounds, particularly for clear film, are certain substituted and chlorinated benzophenones, epoxy compounds, and some of the organotin stabilizers.

Polyethylenes

The large and rapidly expanding use of polyethylenes for high-speed and high-temperature molding has created heat stabilization problems and the need for light stabilizers to improve aging properties.

Stabilization of these polymers is related to the synthetic rubbers and natural rubber, rather than to PVC-type stabilization. Antioxidants of all types are used for



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thermal stability, with carbon black added for most effective outdoor stabilization. Recently, a wide variety of thioethers have shown a synergistic behavior with carbon black (16).

An antioxidant (4,4′-thiobis-(6-tertiary-butyl-m-cresol) has been recommended for electrical insulating and jacketing grades of polyethylene (17).

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Consult the Subject Index for additional information concerning stabilizers. For sources, see Directory Index, p. 1078.

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Plasticizers

By Raymond J. Lawn*

The cellulosics (cellulose nitrate, cellulose acetate, ethyl cellulose, cellulose acetate butyrate, and cellulose acetate propionate) were the first and the major consumers of plasticizers until the advent of World War II. Then the demand created by the military forces for polyvinyl chloride polymers gave impetus to the vinyl industry and, likewise, the plasticizers. On the average, one lb. of plasticizer is compounded with every two lb. of vinyl resin. After the war, the advance continued even more rapidly because of civilian demand. Vinyls assumed leadership in plasticizer consumption and it is estimated that two-thirds of the 400 million lb. annual plasticizer production is consumed in polyvinyl chloride polymer and copolymer fabrication.

Definition and classification

Commercial plasticizers are high boiling organic compounds (usually liquids) which act as solvents for resinous compositions. The incorporation of plasticizers into thermoplastic resinous polymers reduces the secondary attractive forces between the polymer chains, thereby rendering the plastic softer, more flexible, and easier to process.

Among the properties looked for in an ideal plasticizer are: good compatibility; low volatility or permanence; stability to light and heat; absence of color; low temperature flexibility; resistance to extraction by water, soap, oils, greases, and solvents; freedom from odor, taste, and toxicity; resistance to migration; nonflammability; good electrical properties; and bacteria and fungus resistance.

It is customary to classify plasticizers into: primary, secondary, or extenders.

The primary types exhibit high solvency or good compatibility with the resin and may be used as the sole plasticizer. The secondary plasticizers are poor solvators and in most cases cannot be used as the only plasticizer. Nonetheless, the role of the secondary plasticizer is important, since many desirable properties such as low temperature flexibility, plastisol viscosity control, and aging stability can be realized through their judicious use.

The extenders are virtually nonsolvents for the polymer and are used to lower the cost of a particular formulation or compound.

Plasticizable resins

The thermoplastic resins lend themselves to plasticization in the sense that the addition of an external agent effects a more or less permanent softening and flexibility.

Not all thermoplastics accept these softeners nor is it always desirable to plasticize them. Polyethylene, polystyrene, and acrylates can be readily fabricated by heat and/or pressure alone into commercial products, without the use of plasticizers.

Thermoplastic resins which are normally plasticized include: vinyl chloride, vinyl chloride acetate, vinyl acetate, vinyl butyral, vinyl formal, vinylidene chloride, cellulose nitrate, cellulose acetate, cellulose acetate butyrate, ethyl cellulose, cellulose propionate and the acrylic, vinyl acetate, butadiene-styrene and butadiene-styrene-acrylonitrile latices. In addition, small amounts of plasticizers and oils are used with natural and synthetic rubbers to improve processing properties.

Today, one may count no less than 15 synthetic polymer classes and if these are further subdivided into commercial items, the number is well over 50. The Plasticizers Chart starting on p. 560 lists over 350 plasticizers offered by 75 manufacturers.

Theory of plasticization

Thermoplastic monomer units are linked together in the lengthwise direction by strong primary chemical bonds to form the polymer chain. The polymer chain is further bonded to another polymer chain by a secondary force (Van der Waal); the general picture of a resinous mass is a network of long, tangled, and relatively inflexible chains in constant motion.

The primary bonds are not subject to disruption by relatively inactive chemical compounds in which class the plasticizers fall. The secondary forces are not truly chemical and may be likened to tiny magnets, the strength of which may be weakened by separation. It is the frequency of occurrence of these attractive magnetic or polar groups along the polymer chain which affects coherence of the polymer in respect to plasticization.

Plasticizing a thermoplastic resin basically consists of modifying the secondary forces and thereby relieving some of the rigidity of the resin. An effective plasticizer must be one which is sufficiently attracted (polar) to the polymer unions to be able to insert itself between these bonds and replace them with polymer-plasticizer-polymer linkages. Further, plasticizer size can then be effective in weaking additional secondary bonds in the manner of a wedge.

Types of plasticizers

The best known plasticizer for thermoplastic resins is heat, but it is only effective while being applied; once the heat is removed, the original characteristics of the thermoplastic return. However, the addition of an organic chemical compound which is compatible with the resin not only lowers the processing temperature of the thermoplastic but also, if properly selected, such properties as flexibility, softness, etc., can be incorporated into an otherwise unmanageable polymer. These chemical plasticizers may be classified into the following

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*Senior technical representative, Research and Development Dept., Pittsburgh Coke & Chemical Co., Neville Island, Pittsburgh 25, Pa.
Recent Developments and References were prepared by the editors.

broad groups: phthalates; phosphates; aliphatic polybasic acid esters; aliphatic monobasic acid esters; polyglycols and polyesters; epoxy; hydrocarbons and halogenated hydrocarbons; and miscellaneous (sulfonamides, camphor, ethers, pentaerythritol esters, butadiene-acrylonitrile polymers).

The largest prewar usage of plasticizers amounted to approximately 30 million lb.; during the war years the figure more than doubled. For 1958, the estimated production was between 400 and 450 million lb., divided roughly as follows:

	%
Phthalate esters	60.0
Phosphates	12.5
Polybasic acid esters	6.5
Polymerics	8.0
Epoxy	4.5
Miscellaneous	8.5
	100.0

Manufacture

The phthalate esters are prepared, for the most part, from ortho-phthalic anhydride produced from the air oxidation of naphthalene. Several isophthalic esters have recently become commercially available. The phthalates, usually dialkyl phthalates, are manufactured by esterifying a 2 to 10 carbon chain alcohol with the dibasic acid. The alcohols may be normal or iso (oxo process) types. The reaction temperatures range from 130 to 200° C. and the reaction time may vary from 4 to 10 hours depending on the reactants. Esterification is carried out with the aid of acidic catalysts, most common of which are sulfuric and toluene sulfonic acids. The reaction is run under an inert gas atmosphere to keep color formation at a minimum.

On completion of the esterification, the crude ester is refined in several different ways: alkali washing—to neutralize acidic bodies and remove impurities; adsorbent treatment—use of activated charcoal, alumina, or adsorbent clays to remove color impurities; distillation or vacuum stripping—to remove volatile unreacted alcohol. Finally, the phthalate ester may be filtered to free it from solids and to enhance its color.

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A new polymeric plasticizer (*Santicizer 409,* Monsanto Chemical Co.) gives lower odor and color, faster processing speed, better efficiency, greater resistance to extraction and migration, and higher retention of physical properties after heat aging than previous polymerics in the low-cost price range . . . improves low temperature flexibility with no loss of tensile strength and improves fusion properties by 20 percent.

A concentrate (*Puratized,* Gallowhur Chemical Corp.), soluble in most plasticizers, provides superior germicidal properties to the finished product . . . is also self-deodorizing and mold-resistant.

New and improved secondary plasticizer (*Conoco H-35,* Continental Oil Co.) is claimed to be water white and have greater compatibility than other secondaries. Heat and light stability said to be almost equal to DOP . . . suggested for plastisols to help make them less viscous . . . can be used to replace 30% of total plasticizer content in many vinyl formulations.

Epoxidized plasticizing stabilizer produced from pure soybean oil (*Epoxy Gen 80* and *Epoxy Gen 90,* General Mills, Inc.) is claimed to give up to 10% higher epoxy content in the finished product than usual epoxidized oils . . . has up to 50% less impurities and up to 50% less viscosity.

A new epoxy-containing plasticizer (*Flexol 107-D,* Union Carbide Corp.) functions in a double capacity as a plasticizer and vinyl stabilizer . . . is completely compatible with vinyl even at concentrations as high as 70 parts of plasticizer per 100 parts of resin . . . is similar in plasticizing properties to dioctyl phthalate but is less volatile and has stronger solvating power and a somewhat higher brittle temperature.

The phosphates—which include tricresyl, triphenyl, cresyl diphenyl, tributyl, trioctyl, etc.—are made by reacting coal tar or petroleum cresylic acids (mixtures of ortho, meta, and para cresol) and the corresponding alcohol with phosphorus oxychloride or phosphorus pentachloride.

Manufacturing phosphates is somewhat more difficult than phthalates because of corrosion problems involved in handling the hydrochloric acid byproduct. The crude material is refined in much the same way as the phthalates.

Polybasic acid ester manufacture is similar to that of alkyl phthalate esters, the common dibasic acids being adipic, sebacic, and azelaic.

Polymeric plasticizers are polyesters of saturated dibasic acids reacted with ethylene, diethylene, or propylene glycol. The chain is usually terminated with a monobasic fatty acid. Preparation of these esters follow the scheme outlined for phthalates. Temperature requirements for causing the reaction are usually above that of 150° C.

Epoxy plasticizers are the most recent additions to the field. Two general types have been commercialized — epoxy triglyceride esters from soybean oil and the monomeric type such as butyl or octyl epoxy stearates. Several procedures have been used for formation of the oxirane ring on the unsaturated fatty acid esters. One such method is to add hydrogen peroxide to an acetic acid solution of the unsaturated ester in the presence of an acid catalyst.

This addition is usually accomplished at temperatures that range from 60 to 70° C.

Plasticizer properties

Experience has shown that no one plasticizer fills the bill for all types of service. Extensive studies have been conducted for all plasticizer-polymer systems and certain generalizations may be drawn as to performance:

Phthalates. Di (2-ethyl hexyl) phthalate (DOP) and diisooctyl phthalate (DIOP) are the most widely used plasticizers in the vinyl industry. The vinyl performance properties of DOP and DIOP are nearly identical and represent a balance between good compatibility, moderate low temperature flexibility, low volatility, good color stability, and resistance to water. Where a higher degree of permanence or better plastisol viscosity stability is required, diisodecyl (DIDP) or octyl decyl phthalate (ODP) may be chosen. Various combinations of butyl octyl, butyl decyl, or butyl benzyl phthalate coesters are marketed to meet specific requirements of solvation or processing ease. Because dicapryl phthalate (DCP) is a poorer solvator at plastisol compounding temperatures than DOP, it provides plastisols with excellent low viscosity stability, both initially and on aging. Normal octyl, n-decyl phthalate (NONDP) exhibits the best low temperature flexibility-low volatility combination of any commercial phthalate. Another feature of NONDP is good retention of elongation on heat aging. Dibutyl phthalate (DBP) is used mainly in cellulose nitrate lacquers and polyvinyl acetate adhesives, its volatility being too high for most vinyl film applications. Dimethyl (DMP), diethyl (DEP), and di (methoxyethyl) phthalates are preferred for cellulose acetate.

Phosphates: Where it is desired to maintain the flame resistance of vinyls, the phosphates are used in preference to other types of plasticizers. In addition, the phosphates are low in volatility and have good oil-grease resistance and processing qualities. Tricresyl phosphate (TCP) enjoys the largest volume in flame-resistant compositions being used with polyvinyl chloride and cellulose nitrate. TCP has excellent electrical properties and where its deficiency in low temperature flexibility is not a factor, it is used in vinyl insulating compounds. Other commercial phosphates include diphenyl cresyl phosphate, triphenyl phosphate, diphenyl 2-ethyl hexyl phosphate and tri (2-ethyl hexyl) phosphate. Diphenyl 2-ethyl hexyl phosphate is a nontoxic plasticizer. Tri (2-ethyl hexyl) phosphate is superior in low temperature properties; however, its flame and oil resistance is inferior to TCP.

Polybasic acid esters. The more important members of this group are the adipates, azelates, and sebacates; their outstanding properties are low temperature flexibility and viscosity stability in plastisols. Dioctyl-sebacate (DOS) is recognized as a superior plasticizer for use in polyvinyl chloride resins where extreme low temperature flexibility, high efficiency, low volatility, and resistance to soap and water extraction are desired. The properties as well as the economics of the azelates fall between adipates and sebacates, the adipates being the cheapest but the most volatile. Dibutyl sebacate, diisobutyl adipate, monoisopropyl citrate, stearyl citrate, and triethyl citrate have been accepted by the Food and Drug Administration for use in plastic films in contact with food. The butyl and octyl maleates and fumarates are copolymerized with styrene, vinyl acetate, and vinyl chloride for internal plasticization.

Monobasic acid esters. Of this group, the most important members are butyl oleate and stearate which, when used in polyvinyl chloride resins, give softness, low temperature flexibility, and lubricating properties during processing; as these are secondary plasticizers, only small amounts are employed. Castor oil and methyl and butyl ricinoleates are used with cellulose nitrate. Acetyl ricinoleate and acetoxy stearate esters are used in vinyl electrical cable and jacket compounds to increase the retention of elongation properties. Triethylene glycol di (2-ethyl butyrate) is the principal plasticizer for polyvinyl butyral in safety glass.

Epoxies. Epoxy soybean oil in vinyl resins gives a higher degree of permanence and resistance to extraction than monomeric plasticizers; in addition, it acts as a stabilizer in vinyl compositions to both light and heat. The alkyl epoxy stearates include butyl to octyl esters, and while these compounds exhibit better low temperature properties in vinyl than the epoxy oil, they are poorer in volatility and therefore in permanence.

Polyglycols and polyesters (polymerics). Polyethylene glycol polymers find use as plasticizers for proteins, casein, zein, gelatin, and polyvinyl alcohol. Polymerics of the polyester type—i.e., saturated dibasic acids esterified with glycols and terminated with monobasic acids—have outstanding permanence in vinyl plastics. While the polyesters are seldom used alone, in combination with monomeric plasticizers such properties as resistance to migration, extraction by gasoline, oil, water, soap, and detergents, as well as low volatility are realized in polyvinyl chloride formulations. Cellulose nitrate lacquers are also plasticized with polyesters.

Hydrocarbons and halogenated hydrocarbons. Aromatic and paraffinic hydrocarbons are generally considered as secondary or extender type plasticizers.

Ortho-nitrobiphenyl is a low cost primary plasticizer, but its use is limited because of odor and color. Coumarone-indene resins and coal tar oils are compatible with rubbers and some vinyl resins, and these compounds find use in adhesives, floor tile, inks, and rubber compounds. Alkyl naphthalenes aid in lubricating vinyls during processing. α-methyl styrene resins as secondary plasticizers improve the electrical resistance properties of vinyl wire coating compositions. The use of alkylated petroleum aromatic hydrocarbon mixtures as extenders in vinyl chloride plasticizer compositions is limited to dark colored compounds (because of poor color retention properties) and where odor and volatility are not critical. Chlorinated bi-

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phenyls and polyphenyls add flame resistance to plasticized vinyl products. These compounds are also useful in cellulose nitrate and chlorinated rubber lacquers where alkali resistance is a requirement. Hydrogenated terphenyls extend primary plasticizers in polyvinyl chloride resins, but high volatility and poor light stability limit their usefulness.

Chlorinated paraffins are compatible with vinyl chloride resins, rubbers, and cellulose acetate. As secondary plasticizers in vinyls, the chlorinated paraffins add flame resistance, but must be well stabilized against release of chlorine.

Miscellaneous plasticizers: The sulfonamide plasticizers are all toluenesulfonamide derivatives; the o,p-toluenesulfonamide is used to improve the working properties of urea and melamine resins; N-ethyl-p-toluenesulfonamide is used in adhesives of the cellulosic type; N-ethyl-o and p-toluenesulfonamide plasticizes casein and zein.

Polypropylene glycol mono-n-butyl ether is similar to castor oil in plasticization of cellulose nitrate lacquers. The bis-(dimethylbenzyl) ether is an efficient processing agent for nitrile rubber.

Pentaerythritol ester-types are efficient primary plasticizers for polyvinyl chloride resins with lower volatility properties than the octyl phthalate.

Butadiene-acrylonitrile copolymers are resinous type plasticizers which contribute permanence and increased oil resistance to polyvinyl chloride resin formulations.

Compounding

The compounding of a plasticizer with a resinous polymer to be applied from solution is a relatively simple matter of stirring in the plasticizer during some stage of solubilization or after solution of the resin. When the plastic is to be fabricated from an unsolubilized state, i.e., in a dry or dispersed form, much more care has to be taken to insure adequate dispersion of the plasticizer.

Preblending: Solid plastics formulations are usually preblended or premixed to insure uniform dispersion before subjecting the compound to the higher temperatures of processing. The preblending of a vinyl compound is accomplished by mixing the resins, plasticizers, stabilizers, fillers, pigments, and lubricants in dough mixers, mullers, internal mixers, or ribbon blenders.

Premixing may be done at room or elevated temperatures. The so-called "dry blend" or "dry mix" is carried out at high temperatures and the preblend, while hot, may be fed directly to an extruder. This latter method of premixing has the advantage of eliminating heavy mixing equipment.

Plastisols. Plastisols are vinyl resins dispersed in plasticizers. The resins used are physically different from the hot compounding type in that they are smaller and more uniform in particle size. Most commercial dispersion resins range in size from 0.02 to 2 microns in diameter and are called either "stir-in" or "grinding" types.

Stir-in resins, as the name implies, are dispersed by simple stirring of the plasticizer, fillers, pigments, stabilizers, and lubricants until a uniform paste is obtained. The grinding types, after stirring, are ground on a three-roll or stone mill. For some applications, the plastisol is deaerated by applying vacuum to the stirred or ground mass.

All of the compound ingredients associated with hot-processing type resins are used in vinyl dispersions. Plasticizer choice, however, is more critical because of the viscosity or flow characteristics which the plasticizer imparts to the dispersion. Low viscosity plasticizers give low initial viscosities in plastisols; however, a high solvating plasticizer, even of low initial viscosity, will tend to swell the resin particles on aging and cause an increase in viscosity. Often nonsolvent-type plasticizers are employed to control viscosity. Other compounding materials also have a pronounced effect on viscosity and must be chosen carefully.

Organosols. Organosols differ from plastisols in that volatile dispersants and diluents are used in addition to plasticizers to accomplish fluidity. Organosols are usually prepared by dispersing the vinyl resin, plasticizer, and other compounding ingredients in a ball or pebble mill.

Vinyl dispersions may be processed by roller coating, spraying, casting, dipping, and rotational and slush molding. Heat is applied to the dispersion to bring about the fusion of the resin-plasticizer, which occurs when 300 to 350° F. is reached.

References

Consult the Subject Index for additional information on plasticizers. See also the Plasticizers Chart. For sources of plasticizers, see the Directory Index, p. 1078.

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MARKETS FOR PLASTICIZERS

The preceding article on plasticizers gives a firm background in the use of plasticizing materials with various plastics. As indicated, vinyls have outstripped all other plastics in the consumption of plasticizers. It is quite natural, therefore, that marketing and pricing problems have arisen, with definite and far-reaching implications to the entire vinyl field.

The following analysis of costs and markets is adapted from an article which was published in the April 1959 issue of MODERN PLASTICS*, p. 208.*

• • •

When plasticizer manufacturers reduced the list price of dioctyl phthalate (DOP) from 28 to 25¢/lb. it was an attempt to stabilize a situation that has been deteriorating for several years. Very little was sold at the list price of 28¢ as producers maneuvered to meet a plethora of "deals" that existed in the industry. The new price was announced simultaneously with Monsanto's statement that phthalic anhydride had been reduced from 21 to 16½¢ in tank car prices. When phthalic drops in price, DOP can be produced at less cost and Monsanto wasted no time announcing that the DOP price reduction would follow the phthalic decline.

The usual pattern has been for the DOP price to decline 4/10 of a cent for each penny decline in phthalic, but Monsanto shot off both barrels of its shotgun and winged two pigeons at once. They accounted for the price decline in phthalic with one barrel and for the pigeons that had been dealing out DOP at cut prices with the other. It is possible that this move may also help to drive out the off-color DOP material that has been on the market.

It was a foregone conclusion that other producers would reduce the price of phthalic when Amoco announced that its phthalic would be priced at 17¢ when available. The Amoco announcement was made in mid-1958 when the company stated it would go on stream in the near future with a new plant to produce phthalic, isophthalic, and terephthalic by a new oxidizing process. That plant is now about ready for production with a total capacity of from 50 to 60 million lb. a year but there is no certainty on how much of it will be phthalic. The quantity of each of the three depend on components of the crude stream fed into the separator, but talk in the trade is that generally speaking the plant would produce around 10 million lb. of phthalic. This is a tiny amount compared with the 350 million lb. of phthalic used annually but other producers apparently became nervous and lowered the price of their material from its former price of 21¢ even before the Amoco plant had come on stream.

Regardless of the reason, DOP and DIOP plasticizers, which are by far the most widely used of all plasticizers for vinyl chloride compounding, are now 25¢/lb., a new all-time low. They account for at least 120 million lb. of the 310 million lb. of plasticizers used with vinyl chloride. The question now is what effect will this low price have on the use of other plasticizers since DOP and DIOP are generally conceded to have as good (or better) all-around properties as others?

It could be that formulators will use a greater percentage of DOP in their compounds, but plasticizer producers seem confident that other plasticizers which have always been used in smaller proportions in a vinyl compound to impart particular properties will continue as before but possibly in smaller portions.

For example, it is desirable for vinyl drapes to be fire resistant, so they need a portion of phosphate plasticizer. Upholstery, especially automotive type, must have low-temperature flexibility and will need adipates and azelates at 40¢, in a portion of the plasticizer content. Baby pants must be resistant to soapy water and thus create a market for diisodecyl phthalate at 26 cents. Heavy filled sheeting of the type used for pocketbooks may continue to use butyl benzyl which

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is now the same price as DOP but was previously lower cost. Polymeric plasticizers which range up as high as 60¢ will continue to be necessary in gasketing and other materials to help prevent migration.

In the wire coating field there will be a need for such plasticizers as DIDP and the pentaerythritol derived plasticizers that will withstand high temperature and have good electrical properties. In floor tile butyl benzyl and butyl octyl phthalate will always be required because of their improved solvating power.

Normal octyl normal decyl plasticizer, a real high-grade general purpose material that always sold a few cents over DOP, is now 28½¢, but because of its good flexibility properties at low temperature it will probably always be in demand for such applications as upholstery if the price gap doesn't widen.

Dicapryl at 24½ or 25¢ is in demand for plastisols because of its initial low viscosity but there isn't too much of it around, even for those who want it.

Tricresyl phosphate, once in popular demand and especially good for fire resistance, is less used because of its unattractive 32½¢ price.

There are many other examples where higher priced plasticizers will continue to be used to impart special properties to a vinyl compound but that 25¢ price for DOP is certainly a tempting bait for any formulator who thinks he can use more of it and less of the specialty plasticizers to produce an adequate product.

• • •

For a statistical analysis of plasticizer production and sales, with latest available figures from industry and government sources, the reader is referred to p. 182, September 1958 Modern Plastics. *This analysis places the present plasticizer picture in a framework of developments from 1950 to the time of writing.*

In addition, attention should be called to the article "Vinyl plasticizer developments," p. 133, May 1959 Modern Plastics. *Here will be found listed 434 references to literature pertinent to all aspects of plasticizers.*

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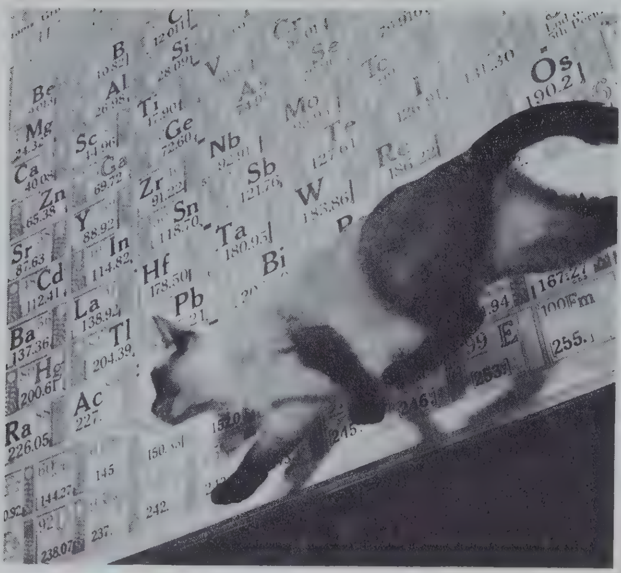

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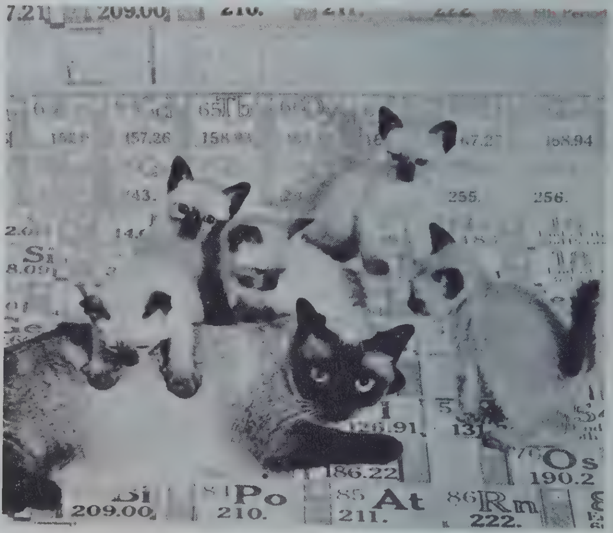

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Periodic Chart of the Atoms, Copyright W. M. Welch Mfg. Company, Chicago

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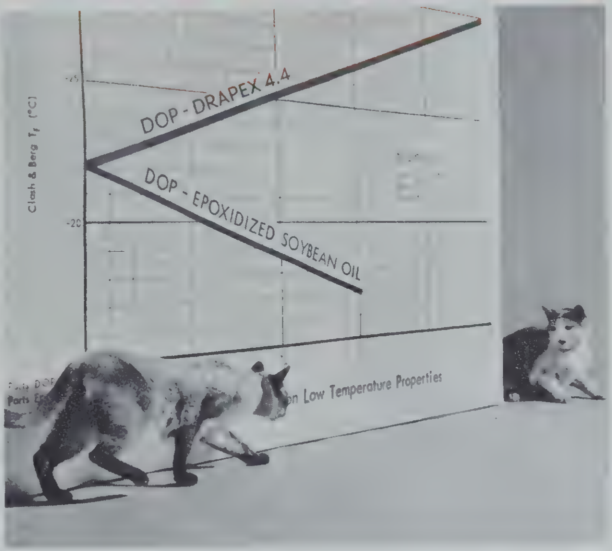

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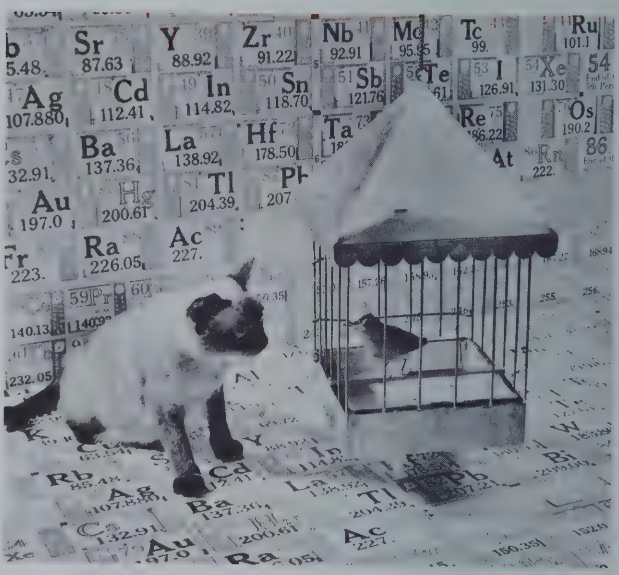

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Mold release agents

Materials which will facilitate the removal of molded plastics parts from the mold surface or surfaces may be applied either directly to the molds or may be incorporated as slip agents in the molding material. In addition, different molding materials and different molding processes require different approaches to the question of mold release. The following discussion has therefore been divided to cover the over-all subject of mold release from the aspects of thermoplastics, thermosets, and slip additives.

While the problems of mold release have long plagued the molder, research into molecular structure and surface phenomena has resulted in important strides forward in overcoming the problems. This article will cover the concepts which a molder should know about when attempting to reach a satisfactory solution.

RELEASE AGENTS FOR THERMOPLASTICS

By Myron C. Borovik*

Since the magnitude of the problem of releasing a molded part from the mold surfaces depends largely on factors other than the choice of a mold release agent, these factors will be considered first and the agents later.

Mold design

The removal of a part from a mold may be divided into two steps: the initial breakaway or surface parting, and the total removal of the part from the mold. Even without any attraction between the surfaces of the part and the mold, it would be impossible to remove a part from a straight cavity or core of any depth because of friction, contact pressure between the materials, and the necessity for working against atmospheric pressure.

The use of draft angles and proper venting have reduced this difficulty but have not eliminated it entirely. Occasionally, the part design will not permit proper draft angles, and wear may have changed the dimensions of old molds, producing undercuts or porous surfaces.

The force required for breakaway depends upon the materials being parted as well as upon the molding conditions. Since thermoplastics are quite viscous at working temperatures, they do not efficiently wet the metal surface and, therefore, large adhering areas do not exist when the material is cooled. Thermoplastic materials are tacky when hot, however, and in heat-sealing operations they tend to stick to and build up on the heater surface.

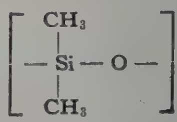
Internal stresses may be present in molded pieces for several reasons; two that are worthy of note are internal pressure caused by cooling under pressure and shrinkage during cooling. Both tend to produce a part with dimensions which are different from those of the injected material before cooling. They create pressure of the part against the mold surface, and considerable force may be required for initial breakaway.

The coefficient of friction and flexibility of a material, in addition to its coefficient of thermal expansion, determine the amount of compensation required in the design of a mold. Materials with lower coefficients of friction slide over the mold surface more readily. Flexibility in the molding material will sometimes permit the removal of parts which have slight undercuts.

Release agents

Release of molded parts may be difficult even when all design precautions are taken. Design, for example, cannot compensate for sticking of material to heat-sealing irons. Also, new metal molds and those which have been idle for some time have a thin, porous, oxide film on their exposed surfaces. Old molds may have eroded in such a way that porosity, slight undercuts, etc., may be present. Certain release materials can drastically reduce the ensuing separation problems. They seem to function as a combination barrier layer and lubricant.

Of the many materials tried as release agents, a silicone, specifically dimethylpolysiloxane, which consists of a chain of



$$\left[-\overset{CH_3}{\underset{CH_3}{\mathrm{Si}}}-\mathrm{O}- \right]_n$$

units, proved outstanding. When spread as a very thin film on the metal surface by means of an aerosol spray applicator, it gives excellent results. It has great heat stability; its decomposition temperature is in the vicinity of 600° F.; and it does not form a carbonaceous film on decomposition. These properties, together with its abhesiveness, make it an excellent release material for metal molds and heat-sealer elements.

The theory of why dimethylpolysiloxane eliminates many of the adhesion problems encountered in the mold shop is pretty much of an educated guess, based on the chemical nature and physical properties of the molecules. The silicon-oxygen linkages in the chain give the molecule its heat stability, high polarity, and extreme flexibility. The methyl groups—the smallest possible organic groups—aid heat stability and flexibility, and present minimum volume to the flowing plastic. When sprayed onto the metal surface, the molecules orient themselves so that the maximum number of polar Si-O bonds attach themselves to the surface atoms of the metal, and the upper part of the layer exposed to the air consists almost entirely of methyl groups. Maximum anchorage to the metal is obtained, and a nonpolar surface of minimum area is exposed to the flowing plastic. In this manner an ex-

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*Borco Chemicals, Inc., 3105 N. Cicero Ave., Chicago 41, Ill.
References were prepared by the editors.

tremely efficient lubricating barrier layer is provided.

In contrast, ordinary oils and waxes do not adhere well to the metal surfaces, and are easily carried away by the hot flowing plastic.

Zinc stearate and other metallic soaps have been used with some success as release materials. Molecules of materials of this type have one polar carboxyl group which anchors to the metal surface, and a long organic chain which is exposed to the material flow. It is obvious that a single point of anchorage is not as strong as the many found with the silicone. Also, the long organic chain exposes most of the molecule to the flowing plastic, and much of the release material is carried away. As would be expected, these materials have release properties intermediate in efficiency between the oil and wax group and the dimethylpolysiloxane.

The properties of dimethylpolysiloxane which make it so good as a release agent also create a problem when molded pieces are to be decorated. An extremely thin film of release agent may be carried over to the molded part and prevent good adhesion of metalizing film, metal foil, and often paint, to the surface of the part. Paint adhesion can be improved by adding a small amount of the silicone, of the order of magnitude of 0.1%, to the paint, or by use of special paint formulations. In addition, at added production cost, some silicone release-agent films can be removed from molded pieces with a solvent or detergent.

Modified silicones and nonsilicone release agents have been developed because of these finishing difficulties. Unfortunately, modification of the basic dimethylpolysiloxane structure to the degree required to give the desired properties involves the substitution of a number of larger organic groups for some of the methyl groups. This interferes with molecular flexibility and thus with alignment on the metal surface. Adhesion to the metal surface is reduced and the larger organic groups are more readily removed by the flowing plastic.

The modified silicones are not much better as release materials than those materials which were used before the silicones were available. The new nonsilicone release materials have about the same release properties as the modified silicones, but must be used in heavier coatings, and often build up on the mold.

Summary

The present state of our knowledge shows that dimethylpolysiloxane is the outstanding material for releasing plastics from metal surfaces. It is not a cure-all for poor mold design or improper molding techniques, but it has a useful place in both molding and heat-sealing operations.

Modification of the silicone molecule to permit metalizing or painting surfaces of molded parts are primarily self-defeating. The properties which make the silicone a good release material are reduced directly in proportion to the degree to which it loses its molecular flexibility, and the extent to which it more readily accepts surface decoration.

Good housekeeping needed

The use of silicone sprays in a mold shop requires good housekeeping practices on the part of the molder. An adequate ventilating system should be used because particles of silicone spray can be carried for long distances by air currents. Raw material and work to be finished should be kept covered, and metalizing and painting operations should be done in a separate room or in one in which air motion is toward the molding section from the finishing operation. If these precautions are taken, the silicone aerosol spray can be a useful item in every mold shop.

RELEASE AGENTS FOR THERMOSETS

By James S. Lunn*

In molding most thermosets of the low-pressure (usually reinforced) type, i.e., polyesters and epoxies, the pressure-*versus*-flow problem hardly exists. Here the need is for a barrier agent to prevent adhesion of the part to the mold. This agent must be inert to the mold material and the resin being molded, as well as to the reinforcements, fillers, catalysts, and pigments.

Molding of high-pressure thermoset compounds, i.e., melamine, phenolic, urea, etc. poses a combination of the above problems. Agents incorporated into the molding compound (which consequently reduce pressure requirements) and barrier agents applied to the mold surface (which also promote flow) are used to facilitate release. Generally speaking, these thermoset resins are not as adhesive in nature as the low-pressure variety.

In reinforced plastics molding, it is imperative that in addition to use of the proper release agent, the molds be cleaned carefully, filled, and polished.

Porous molds such as those made of plaster, ceramics, wood, and concrete should be thoroughly dried after cleaning. Plaster molds retain their dampness a long time and it is necessary to dry them from 3 to 12 days in a circulating-type warm air oven at 125 to 150° F. A sealer which does not affect the mold or mold material should be applied carefully on porous molds.

Cast or wrought metal molds do not require a sealer but must be cleaned and polished. In reinforced plastics molding, highly-polished steel or plated molds, once broken in, necessitate little treatment with release agents.

To achieve the smoothest luster, expert sanding of the surface with a 320 or 400 grit is required, then polishing with a buffing compound, taking care that waviness is removed, especially on side walls where release of the part is a function of shear between the part and the mold.

Types of releases

Mold release agents are available in the following forms: 1) films; 2) film-forming solutions;

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*President, Lunn Laminates, Inc., Huntington Station, L.I., N.Y.

3) waxes in solid, paste, and liquid forms; 4) lubricants in various viscosities; and 5) powders.

1) *Films* such as cellophane or polyvinyl alcohol are available in clear transparent or colored for easy identification. Generally, films can be used only once and are suited only for flat or simple curved surfaces. Such film cannot be used over compound curves because of wrinkling, unless preformed in advance by drawing. Films can be applied over unsealed porous molds, as the material is tough enough to bridge mold pores and voids. PVA sheeting is soluble in water, so care should be taken to keep it dry and use it only on well-dried mold surfaces.

2) *Film-forming parting agents* are generally used in the reinforced plastics industry for bag and contact molding on porous molds of compound curvature such as plastic, wood, plaster, and concrete. An impervious barrier is formed, thus preventing the resin from attacking the mold chemically or mechanically. Spray-type film-forming agents are quickest and easiest to use, and produce glossy surfaces.

3) *Waxes* may be used as combination parting agent and sealer on porous molds. As a mold sealer they work best under a film-forming parting agent. Waxes generally leave a carbonaceous deposit on the finished part and the mold. To ease the problem, water-soluble waxes have been developed which permit the wax to be applied in a molecular-thin coating on the mold which leaves no apparent deposits on the surface after repeated cycling.

4) There are many varieties of *lubricants* used as parting agents. The individual molder should try several kinds to ascertain which work best for him. Lubricants are preferred to waxes by most reinforced plastics molders for polished or plated steel molds, as they do not leave deposits on the mold surfaces to the extent waxes do. When proper lubricants are used on polished or plated steel molds, good release can be obtained and the mold requires only occasional relubricating.

Petroleum jelly is used on aluminum molds with successful results; stearic acid is preferred for phenolics but should not be used with polyester resins as it inhibits the cure; oil and grease graphite mixtures have been used sucessfully with polyesters; silicones are good parting agents for phenolic molds and possess high flash and fire points with superior resistance to oxidation.

5) *Powders:* Stearates made from aluminum, barium, butyl, calcium, lead, magnesium, and zinc base are the better-known powder preparations. The disadvantage of the possible remaining dust particles, which affects the surface finish, has curtailed extensive use of these powdered substances for mold release purposes.

SLIP AGENTS FOR THERMOPLASTICS

By Thomas E. Molnar*

Slip agents are now so widely used in the processing of thermoplastics, particularly the polyolefins, that many processors may be using resins containing slip additives without realizing it. Many resin makers routinely add slip agents to certain grades of polyethylene. A knowledge of the capabilities and limitations of the additives is, therefore, essential to the processor to whom it is important to get the most out of his investment.

Slip agents function by providing a lubricating film on the surface of a plastic product. This film forms rapidly as the resin cools from processing temperatures. The ability of the additive to form a lubricating film very rapidly stems from the marked variation in solubility of the additive in resins as the temperature varies. Thus, as the resin cools, it tends to force the additive out of solution and on to the surface of the cooling mass.

In the case of properly chosen additives, the film deposition is so rapid that a good lubrication film is formed in less than the time that is required for the resin to pass through the extruder.

The presence of such a lubricating film within the extruder die allows the extruded material to pass through the die more rapidly. Extrusion rates can often be increased as much as 25% by including a slip agent in the plastic formulation. Similarly, slip agents may be used to decrease cycle time in an injection molding operation. In addition, the surface films formed by slip agents act as a mold release and reduce blocking in sheet and film products.

A good slip agent must not only be capable of forming a lubricating film rapidly on the surface of a cooling resin mass, but must also have a number of other characteristics which are less obvious.

It must have a physical form which permits easy blending with resin pellets. (Although many polyolefin producers include slip agents in their products, individual processors frequently find it advantageous to increase the amount of additive.) The slip agent must neither discolor nor impart an unpleasant odor or taste to the finished plastics article and, if the plastics article involved may come in contact with food, the slip additive must be approved by the Food & Drug Administration. A good slip agent must also be stable under the normal conditions of storage and use.

Slip agents have a definite and important place in the field of thermoplastic processing. If the processor is aware of the capabilities of slip agents and of the requirements which a good slip agent must meet, he can use slip agents to increase his profits and the quality of his product.

References

Consult the Subject Index for additional information concerning mold release agents. For sources of mold release agents, see Directory Index, p. 1078.

"Integral lubrication of polystyrene," by R. B. Bishop, Modern Plastics *33*, 141 (Oct. 1955).

"Plastics processing," Lubrication *39*, 129 (Nov. 1953).

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*Chief, Development section, Fine Organics, Inc., 205 Main St., Lodi, N.J.

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LOWER ALCOHOLS	TYPICAL INSPECTIONS	APPLICATIONS
ETHYL ALCOHOL (This alcohol is used by Enjay in preparing denatured alcohols, including Jaysol® and Jaysol® S Proprietary Solvents)	Color, Pt-Co . . . <5 Purity, Vol. % . . . 95.1 Sp. Gr., 20/20°C. . . . 0.8122 Lbs./Gal., 60°F. . . . 6.8 Distillation, °C. IBP . . . 78.0 DP . . . 78.6 Flash, T.O.C., °F. . . . 68	Acetaldehyde, Acetic Acid, Vinegar, Shellac Solvent, Ethyl Ether, Pharmaceuticals, Toiletries, Liquid Detergents, Solvent
ISOPROPYL ALCOHOL†, 91% (Petrohol®, 91%)	Color, Pt-Co . . . <5 Purity, Vol. % . . . 91.5 Sp. Gr., 20/20°C. . . . 0.8175 Lbs./Gal., 60°F. . . . 6.8 Distillation, °C. IBP . . . 79.7 DP . . . 80.3 Flash, T.O.C., °F. . . . 62	Acetone, Solvent Extraction, Toiletries, Liquid Detergents, Cleaners, Solvent
ISOPROPYL ALCOHOL, ANHYDROUS (Petrohol®, Anhydrous)	Color, Pt-Co . . . <5 Purity, Vol. % . . . 99.9+ Water Content, Wt. % . . . 0.05 Sp. Gr., 20/20°C. . . . 0.7858 Lbs./Gal., 60°F. . . . 6.6 Distillation, °C. IBP . . . 82.0 DP . . . 82.4 Flash, T.O.C., °F. . . . 60	Aerosols, Lacquer Solvent (Latent), Isopropyl Acetate, Solvent Extraction, Solvent, Carburetor Anti-icing
SECONDARY BUTYL ALCOHOL	Color, Pt-Co . . . <5 Purity, Wt. % . . . 99.7 Water Content, Wt. % . . . 0.1 Sp. Gr., 20/20°C. . . . 0.808 Lbs./Gal., 60°F. . . . 6.7 Distillation, °C. IBP . . . 99.4 DP . . . 100.4 Flash, T.O.C., °F. . . . 85	Methyl Ethyl Ketone, Lacquer Solvent (Latent) Sec. Butyl Acetate, Sec. Butyl Xanthate, Solvent

†Enjay also supplies Isopropyl Alcohol, 95%

HIGHER OXO ALCOHOLS	TYPICAL INSPECTIONS	APPLICATIONS
ISOOCTYL ALCOHOL (A mixture of 8 carbon primary alcohols)	Color, Pt-Co . . . <5 Purity, Wt. % . . . 99.6 Water Content, Wt. % . . . 0.06 Sp. Gr., 20/20°C. . . . 0.832 Lbs./Gal., 60°F. . . . 6.9 Distillation, °C. IBP . . . 184 DP . . . 191 Flash, T.O.C., °F. . . . 180+	Plasticizers, Antifoams, Synthetic Lubricants, Metal Extraction, Surfactants, Herbicides, Vinyl Stabilizers, Solvent

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HIGHER OXO ALCOHOLS (Continued)	TYPICAL INSPECTIONS	APPLICATIONS
DECYL ALCOHOL (A mixture of primary alcohols)	Color, Pt-Co: <5 Purity, Wt. %: 99.5 Water Content, Wt. %: 0.06 Sp. Gr., 20/20°C.: 0.838 Lbs./Gal., 60°F.: 6.9 Distillation, °C. IBP: 215 DP: 221 Flash, T.O.C., °F.: 210	Plasticizers, Antifoams, Synthetic Lubricants, Metal Extraction, Surfactants, Herbicides, Vinyl Stabilizers
TRIDECYL ALCOHOL (A mixture of 13 carbon primary alcohols)	Color, Pt-Co: <5 Purity, Wt. %: 99.5 Water Content, Wt. %: 0.05 Sp. Gr., 20/20°C.: 0.845 Lbs./Gal., 60°F.: 7.0 Distillation, °C. IBP: 245 DP: 257 Flash, T.O.C., °F.: 240	Surfactants, Plasticizers, Metal Working Lubricants, Textile Lubricants, Bactericides

ETHERS	TYPICAL INSPECTIONS	APPLICATIONS
ETHYL ETHER (Supplied inhibited and uninhibited)	Color, Pt-Co: <5 Purity, Wt. %: 99.3 Sp. Gr., 20/20°C.: 0.715 Lbs./Gal., 60°F.: 6.0 Flash, T.O.C., °F.: −40	Solvent Extraction, Ethylene, Explosives, Collodion, Solvent
ISOPROPYL ETHER, 94% (Supplied inhibited)	Color, Pt-Co: <5 Purity, Wt. %: 94.6 Sp. Gr., 20/20°C.: 0.728 Lbs./Gal., 60°F.: 6.1 Distillation, °C. IBP: 33 DP: 98 Flash, T.O.C., °F.: −4	Solvent, Antiknock Agent

ESTERS	TYPICAL INSPECTIONS	APPLICATIONS
ETHYL ACETATE (Two grades of ethyl acetate are sold by Enjay. The commonly used grade (85-88%) is represented here. A 99-100% grade is available for those uses where the presence of 12-15% ethyl alcohol is undesirable)	Color, Pt-Co: <5 Purity, Wt. %: 88 Sp. Gr., 20/20°C.: 0.886 Lbs./Gal., 60°F.: 7.4 Distillation, °C. IBP: 71.5 DP: 77.6 Flash, T.O.C., °F.: 40	Lacquer Solvent, Solvent Extraction, Denaturant, Adhesives, Solvent

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ESTERS (Continued)	TYPICAL INSPECTIONS	APPLICATIONS
ISOPROPYL ACETATE	Color, Pt-Co .... <5 Purity, Wt. % .... 96.2 Sp. Gr., 20/20°C....... 0.870 Lbs./Gal., 60°F. .... 7.3 Distillation, °C. IBP .... 86.5 DP .... 88.5 Flash, T.O.C., °F....... 49	Solvent: Lacquers, Extraction, General
SECONDARY BUTYL ACETATE	Color, Pt-Co .... 10 Purity, Wt. % .... 88 Sp. Gr., 20/20°C....... 0.862 Lbs./Gal., 60°F. .... 7.2 Distillation, °C. IBP .... 106 DP .... 113 Flash, T.O.C., °F....... 89	Solvent: General, Lacquers, Textile Sizes, Paper Coatings

KETONES	TYPICAL INSPECTIONS	APPLICATIONS
ACETONE	Color, Pt-Co .... <5 Purity, Wt. % .... 99.7 Sp. Gr., 20/20°C....... 0.793 Lbs./Gal., 60°F. .... 6.6 Distillation, °C. IBP .... 55.9 DP .... 56.3 Flash, T.O.C., °F....... 8	Solvent: Extraction, Lacquers, Plastics, Coatings, Textiles, General; Higher Alcohols and Ketones
METHYL ETHYL KETONE	Color, Pt-Co .... <5 Purity, Wt. % .... 99.7 Sp. Gr., 20/20°C....... 0.806 Lbs./Gal., 60°F. .... 6.70 Distillation, °C. IBP .... 79.0 DP .... 80.0 Flash, T.O.C., °F....... 22	Solvent: Extraction, Lacquers, Rubber, General, Coated Fabrics; Lube Oil Dewaxing

OLEFINS	TYPICAL INSPECTIONS	APPLICATIONS
ETHYLENE (Supplied as a compressed gas)	Purity, mole % 99.5	Ethyl Alcohol, Polyethylene, Ethylene oxide, Styrene, Ethyl Chloride
PROPYLENE CONCENTRATE (Supplied as a liquefied gas)	Purity, mole % 89	Isopropyl Alcohol, Propylene Trimer, Propylene Tetramer, Propylene Oxide, Polypropylene, Cumene

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OLEFINS (Continued)	TYPICAL INSPECTIONS		APPLICATIONS
ISOBUTYLENE (Supplied as a liquefied gas)	Purity, Wt. %	99.3	Butyl rubber, Vistanex®, Lube Oil Additives, Antioxidants, Alkylate Gasoline
	Sp. Gr., 60/60°F.	0.602	
	Lbs./Gal., 60°F.	5.0	
TRIPROPYLENE	Olefins, Vol. %	99+	Nonylphenol, Nonylbenzene, Lube Oil Additives, Wetting Agents
	Color, Pt-Co	5	
	Sp. Gr., 20/20°C.	0.738	
	Lbs./Gal., 60°F.	6.1	
	Distillation, °F.		
	IBP	249	
	DP	297	
	Flash, T.O.C., °F.	75	
NONENE, CLOSE CUT	Olefins, Vol. %	99+	Nonylphenol, Nonylbenzene, Lube Oil Additives, Wetting Agents, Decyl Alcohol
	Color, Pt-Co	5	
	Sp. Gr., 20/20°C.	0.740	
	Lbs./Gal., 60°F.	6.2	
	Distillation, °F.		
	IBP	268	
	DP	285	
	Flash, T.O.C., °F.	78	
TETRAPROPYLENE	Olefins, Vol. %	99	Detergent Alkylate, Tridecyl Alcohol, Wetting Agents, Dodecylphenol
	Color, Pt-Co	40	
	Sp. Gr., 20/20°C.	0.780	
	Lbs./Gal., 60°F.	6.5	
	Distillation, °F.		
	IBP	360	
	FBP	435	
	Flash, T.O.C., °F.	150	

DIOLEFINS	TYPICAL INSPECTIONS		APPLICATIONS
BUTADIENE (Supplied as a liquefied gas)	Purity, Wt. %	98.6	SBR Rubber, Polybutadiene Rubber, Resins, Nylon, Nitrile Rubber
	Lbs./Gal., 60°F.	5.2	
ISOPRENE	Color	Light Yellow	Butyl Rubber, Resins, "Synthetic Natural" Rubber
	Purity, Wt. %	95	
	Sp. Gr., 60/60°F.	0.685	
	Lbs./Gal., 60°F.	5.7	
	Flash, T.O.C., °F.	—65	
DICYCLOPENTADIENE	Color, Pt-Co	50	Insecticides, Resins, Varnishes, Ferrocene Compounds, Paints, Norbornylene, Diels-Alder Adducts
	Purity, Wt. %	96.0	
	Sp. Gr., 20/20°C.	0.979	
	Lbs./Gal., 60°F.	8.20	
	Flash, T.O.C., °F.	80-100	

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AROMATICS	TYPICAL INSPECTIONS	APPLICATIONS
BENZENE	Purity, Wt. % . . . . 99+ Freezing Pt., °C. . . . 5.39 Sp. Gr. 60/60°F. . . . 0.884 Lbs./Gal., 60°F. . . . 7.4 Distillation, °C. IBP . . . . 79.5 DP . . . . 80.1 Flash, T.O.C., °F. . . . 40	Styrene, Phenol, Nitrobenzene, Aniline, Detergent Alkylate, Insecticides
PARA XYLENE	Purity, Wt. % . . . . 98.1 Freezing Pt., °C. . . . 11.5 Sp. Gr. 60/60°F. . . . 0.865 Lbs./Gal., 60°F. . . . 7.2 Flash, T.O.C., °F. . . . 103	Textiles, Film, Terephthalic Acid
ORTHO XYLENE	Purity, Wt. % . . . . 95.1 Sp. Gr. 60/60°F. . . . 0.882 Lbs./Gal., 60°F. . . . 7.4 Flash, T.O.C., °F. . . . 115	Phthalic Anhydride
AROMATIC HB (A dark colored liquid high in aromatics)	Lbs./Gal., 60°F. . . . 7.6 Viscosity, SSU, 100°F. . . . 45 Flash, T.O.C., °F. . . . 180+ Pour Point, °F. . . . −10	Solvent for Wood Preservatives and Insecticides; Heat Exchange Fluid
AROMATIC CONCENTRATE (A dark colored viscous liquid high in aromatics)	Lbs./Gal., 60°F. . . . 8.9 Viscosity, SSU, 210°F. . . . 77 Flash, P-M, °F. . . . 230 Pour Point, °F. . . . 45	Carbon Black, Dark Resins
AROMATIC TAR S-2	Lbs./Gal., 60°F. . . . 8.9 Viscosity, SSU, 210°F. . . . 120 Flash, P-M, °F. . . . 230+	Carbon Black

MISCELLANEOUS	TYPICAL INSPECTIONS	APPLICATIONS
CYCLOHEXANE	Color, Pt-Co . . . . <5 Purity, Wt. % . . . . 98.5 Sp. Gr., 60/60°F. . . . 0.781 Lbs./Gal., 60°F. . . . 6.5 Distillation, °F. IBP . . . . 177 DP . . . . 178.5 Flash, T.C.C., °F. . . . 1	Nylon, Cyclohexanone
CTLA POLYMER (A dark viscous liquid of high unsaturates content)	NVM, Wt. % . . . . 94 Iodine No. Cg./g. . . . 247 Lbs./Gal., 60°F. . . . 8.3 Flash, C.O.C., °F. . . . 230+	Core Oils, Rubber Reclaiming, Hardboard Tempering Fluid
LP DISTILLATE (A clear yellow liquid rich in vinyl aromatics)	Lbs./Gal., 60°F. . . . 7.2 Distillation, °F. IBP . . . . 200 FBP . . . . 480 Flash, T.O.C., °F. . . . 77	Resins, Aromatic Solvents

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MISCELLANEOUS (Continued)	**TYPICAL INSPECTIONS**	**APPLICATIONS**
NAPHTHENIC ACID (A dark liquid mixture of carboxylic acids with a range in molecular weights)	Acid No. Mg KOH/g . . . . 212 Lbs./Gal., 60°F. 8.2	Paint Driers, Preservatives, Greases

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Solvents

By John W. Wyart* and N. G. Baker*

Solvents are selected from the broad category of industrial chemicals because of a specific property—their ability to dissolve other substances. In a sense, they can be considered as processing agents whose function is to facilitate the use of a solid substance for some particular application.

Solvents are selected from a large field of chemicals and often serve multiple functions. In addition to their solvent uses, they can be used as intermediates for preparation of other chemicals, or to supply certain physical properties to a mixture of ingredients. Some applications in which solvents are used other than for their dissolving actions are in extraction processes, concentration of pharmaceutical products, ore flotation, dry cleaning, automobile antifreezes, and hydraulic fluids, among others. A major use for solvents, however, continues to be as processing agents in dissolving resinous substances for the coating and adhesive industries. The textile industry also uses large quantities of organic solvents, particularly in the spinning solutions for cellulose acetate fibers.

Development

The modern solvent industry started with the fermentation process developed during World War I for the production of acetone and butanol. Acetone was urgently needed for the war effort and, consequently, large facilities were erected for its production. Since butanol was a co-product of the process, it quickly became a surplus item.

For every pound of acetone, 2 lb. of by-product butanol were also produced. The growth which the plastics industry has witnessed is related to this butanol surplus.

In an effort to develop an outlet for this surplus, it was reacted with acetic acid to produce butyl acetate, found to be an excellent solvent for cellulose nitrate.

Cellulose nitrate, when it was dissolved in butyl acetate and modified with resins, produced a quick-drying, attractive, tough, and durable substitute for paint and varnish needed by the automotive industry. This was the start of volume lacquer usage. Automotive production which had previously been bottlenecked due to the slow drying properties of the paints previously used, was increased considerably. It was not long before other industries followed the lead of the automotive industry. Artificial leather utilized the new lacquer coating. The paper and furniture industries also began to finish their products with it. With this beginning, it was not long before other means than the fermentation of starch and sugars were used to produce butanol and other solvents for the new coatings industry.

Fermentation is still used as a means of manufacturing solvents. Some ethyl alcohol is produced from the fermentation of grain and black strap molasses and some butanol and acetone are also produced by fermentation. By and large, however, the solvent industry has come to depend on petroleum and coal by-products as a source of raw materials rather than such agricultural products as grain, molasses, corn, etc. Solvents that are manufactured by synthetic methods from these hydrocarbon products are more stable in their price structure than solvents manufactured from agricultural products. These latter types of solvents show wide price fluctuation as their raw materials alternately become scarce or are in oversupply.

Synthetic production

The first step toward synthetic production of solvents came when the hydrogen and carbon dioxide by-products of fermentation were utilized for the preparation of methanol. In addition to its solvent uses, this alcohol is widely used in automobile antifreezes and as an intermediate for the production of formaldehyde.

Formaldehyde reacted with phenol and urea led to a whole series of new plastic materials which could be utilized in solvent solutions as coatings. It can be seen that the tremendous growth of the coating industry in general is closely intertwined with the growth in solvent production. This came about not only because of the processing improvements in coating application due to the availability of new solvents, but also by the utilization of these solvent materials as chemical intermediates for production of new resins and plasticizers. These in turn prompted the development of new solvents for their processing.

Oxygenated solvents

The volatile polar liquids such as the ketones, esters, glycol-ethers, etc., are of considerable importance in the coatings industry. These solvents are needed to disperse and dissolve the more difficultly soluble macromolecular substances.

Esters: The original nitrocellulose solvents were butyl, ethyl, and amyl acetate.

Esters, of which the acetates represent the only commercially important members, are produced by reacting commercial alcohols with acetic acid or anhydride. In some cases, esters are produced as by-products in an ester interchange reaction, or by ester hydrolysis in the presence of alcohol. Methyl acetate, for example, is obtained as a by-product from the hydrolysis of polyvinyl acetate to polyvinyl alcohol. Almost all of the lower-priced alcohols are esterified for use as active solvents for resinous materials. Therefore, as more alcohols are made commercially available, the number of esters available will also increase.

Alcohols: Ethyl alcohol is the most important member of this class of chemicals. It is used as a solvent for shellac and various other resins, as a latent solvent for nitrocellulose, and an inter-

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* Celanese Corp. of America, 180 Madison Ave., New York, N. Y.
References were prepared by the editors.

TABLE I: Solvent production statistics[1]

Solvent	*Solvent production, in million lb.*			
	1940	*1950*	*1955*	*1957*
Acetone	202	482	538	651
Butyl alcohols	165	323	475	487
Butyl acetate (90%)	87	77	82	72
Ethyl acetate	75	92	85	92
Ethyl alcohol	1060[2]	1090	1214	1351
Ethyl ether	22[2]	38	69	80
Ethylene glycol	140	519	888	1200
Halogenated hydrocarbons	—	2089	3494	4187
Isopropyl alcohol	220	866	854	1191
Methanol	159	915	1343	1521

[1] Source: U. S. Tariff Commission
[2] 1941 figures

mediate for a great many organic compounds. Ethyl alcohol is still produced in quantity by the fermentation of molasses and grain. In the last few years, however, synthetic material has made heavy inroads into the fermentation alcohol market. The quality of the synthetic product is equal to that of the fermentation grade.

Methanol is produced primarily by direct oxidation of hydrocarbon, although some wood distillation is still carried on. This alcohol is an excellent solvent for nitrocellulose, ethyl cellulose, natural and synthetic resins, etc. It is the most active of the aliphatic alcohols in solvent power; however, its industrial application is restricted somewhat by its high toxicity and its volatility. Methanol finds extensive use as an intermediate, principally for the production of formaldehyde. Both normal propyl and isopropyl alcohols are produced by hydrocarbon oxidation, with the latter alcohol assuming the greater importance. Isopropyl alcohol is produced in the greatest quantity of any alcohol except ethanol. It is used widely as a latent solvent in nitrocellulose lacquers. Its properties are similar to those of ethanol.

Butyl alcohol: All four isomers of butyl alcohol are produced commercially, with normal butyl alcohol finding widest application as a solvent. This alcohol is produced synthetically by the aldol condensation of acetaldehyde.

Higher alcohols: Amyl, hexyl, and octyl alcohols, and alcohols of even greater carbon chain length are produced commercially. Alcohols higher than 6 carbons (hexyl alcohol) are not frequently used as solvents due to their low volatility. These alcohols find widespread use as intermediates for plasticizers where low volatility is required.

Ketones: These chemicals have come into widespread use as solvents for resinous materials. Three are of great commercial importance—acetone, methyl ethyl ketone, and methyl isobutyl ketone. Acetone is the most important member of the group. It is produced in great quantities by oxidation of isopropyl alcohol. Acetone is an excellent solvent for nitrocellulose and most other cellulose resins although somewhat volatile for coating needs.

Methyl ethyl ketone is produced from secondary butyl alcohol. As the second member of the aliphatic ketone series it is less volatile than acetone and hence widely used in coating formulations. Methyl isobutyl ketone contributes flow to lacquers and is a good blush retarder.

Function of a solvent

Most of the resins available in industry for coating purposes are hard and brittle substances. Others are less hard and some are even soft tacky materials. All of these have to be made fluid and the particles welded together to can be considered a coating.
form a continuous film before it

Provided the chemical structure of the resin is not altered, this fluid workable state can be achieved by heating the resin or by dispersing it in a solvent. These properties exist only while the heat is applied or while the solvents are in association with the resin. Removal of either causes the resin to revert to its original unworkable state. In this respect, a solvent differs from a plasticizer. An important difference in the use of plasticizers and solvents, of course, is that solvents are always used in fairly large amounts to produce a liquid material, whereas plasticizers are used in smaller quantities to produce a flexible yet still solid product.

In order to understand better the behavior of solvents and resin, we might consider the structure of a resin before and after the addition of a solvent. A resin appears to be a three-dimensional network of macromolecules. Each of these molecules has attracting points along its chain. These attracting points can attract each other, thereby setting up secondary forces of attraction between resin macromolecules. If these attracting centers are many and strong, the forces of attraction will be such that a very close-packed, rigid structure will result. Such a resin will be hard and brittle. If, however, there are few attracting centers, and if they are relatively weak, then a flexible material will result. These bonding forces between molecules are actually equilibrium forces, for if we heat or cool the resin we will affect the properties, thereby indicating that motion resulting from freedom in the mass is still possible. It can be said that an aggregation-disaggregation equilibrium exists between the molecules.

If a solvent is introduced into the resin, its molecules, being much smaller and more mobile, will move in and around the molecule of the resin. This movement in and around the resin molecule causes a physical separation by actual breaking of the secondary valence bonds. In addition, since the solvents are polar materials, they will be attracted to the attracting center on the resin macromolecule, and will compete with other resin macromolecules for these centers. This solvation is also an equilibrium process and the solvent molecule after momentary attachment is replaced by another solvent molecule or another resin macromolecule attracting center. Thus, there is a solvation-desolvation equilibrium. There are then two competing equilibria, solvation-desolvation of the solvent molecules and aggregation-disaggregation of the resin macromolecules. Obviously, a change in equilibrium in favor of solvation-desolvation would increase functionality.

Cellulose nitrate coatings

Cellulose nitrate, in order to be used as a coating material, is dissolved in a mixture of solvents. This mixture is called the thinner and is composed of liquids that have varying degrees of solvent power for the polymer. They are broadly classified as active solvents, latent solvents, and diluents. The liquids described as active solvents actually dissolve the polymer. Most of these are polar compounds containing oxygen-bearing groups. Aliphatic esters and ketones are the active solvents most commonly employed. Latent solvents are always alcohols. They do not promote solvation of the polymer by themselves. However, they usually add to the solvating effect when used in conjunction with the active solvents. Diluents are used to dilute and cheapen the thinner and are usually aliphatic and aromatic hydrocarbons.

Various tests have been developed to determine the effectiveness of a thinner as a dissolving agent. These indicate, in a practical sense, the application characteristics of such solutions. The degree of solution is indicated by the viscosity, since it is this property that indicates whether the lacquer is in a proper state of fluidity. The degree of fluidity dictates the method of application, e.g., spraying, brushing, or other techniques.

Second in importance is the tolerance of the lacquer for hydrocarbon diluents. This indicates whether the thinner has been formulated in the most economical manner. A high dilution ratio, for instance, would indicate that the thinner could stand further dilution.

Since these coatings dry by solvent evaporation, the rate of this evaporation is all-important in determining the properties of the film. Practical tests have been developed to indicate whether a thinner is evaporating properly. Determination of blush resistance of a lacquer often indicates whether or not a thinner is too fast. Blush resistance is determined by observing the degree of relative humidity at which precipitation of the film occurs. This is a function of the temperature of the film's surface as well as of the relative humidity. Therefore, a thinner that dries too rapidly will produce too great a cooling effect at the surface.

In formulating cellulose nitrate lacquers, it is generally desirable to use solvents that combine good solvent power with relatively slow evaporating properties. It is not usually easy to do this. Solvents that are most effective in reducing viscosity, such as ethyl acetate, methyl ethyl ketone, etc., also evaporate most rapidly.

Standard cellulose nitrate lacquer thinner formulations are designed to evaporate in a fairly constant manner. Thus, a graph of the evaporation rate would approach a straight line. These thinners are usually balanced with equivalent parts of fast-, medium-, and slow-evaporating solvents and diluents.

There are two major deviations from this type of formula. One is the thinner used with hotspray lacquers. In these formulations, heat is used to aid viscosity reduction, since cellulose nitrate solvency is also a function of the temperature. Medium- and slow-evaporating solvents are used in these thinners.

The other deviation is classified as the "high-build thinners." In this type of formulation, only fast-evaporating solvents that are also good viscosity-reducing materials are used in conjunction with slow solvents, with little emphasis being placed in the medium boiling range. Both of these lacquers find wide use in fields where the equipment necessary for their application is available.

Vinyl resins

Vinyl resin solutions differ from conventional nitrocellulose solutions although many of the same solvents and diluents are used in both types. Most of the vinyl

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resins used for solution coatings are copolymers of vinyl chloride and vinyl acetate, with the vinyl acetate constituting about 17% of the product.

Solution coatings based on vinyl resin differ in several important ways from the conventional pyroxylin lacquers. They are less susceptible to blushing, and show greater resistance to certain solvents and to weathering. In addition, they show limited compatibility with modifying resins, possess rather poor adhesion at air-drying temperature, and have a tendency toward orange peel.

The vinyl resins used for solution coating are usually dissolved in ketones and diluted with aromatic hydrocarbon. Since blushing is not a factor and since the films are usually baked, fast-evaporating solvents can be used. Formulations are simple, compared to the highly-modified nitrocellulose lacquers. Usually, one or two vinyl copolymers and one or two solvents constitute a formula.

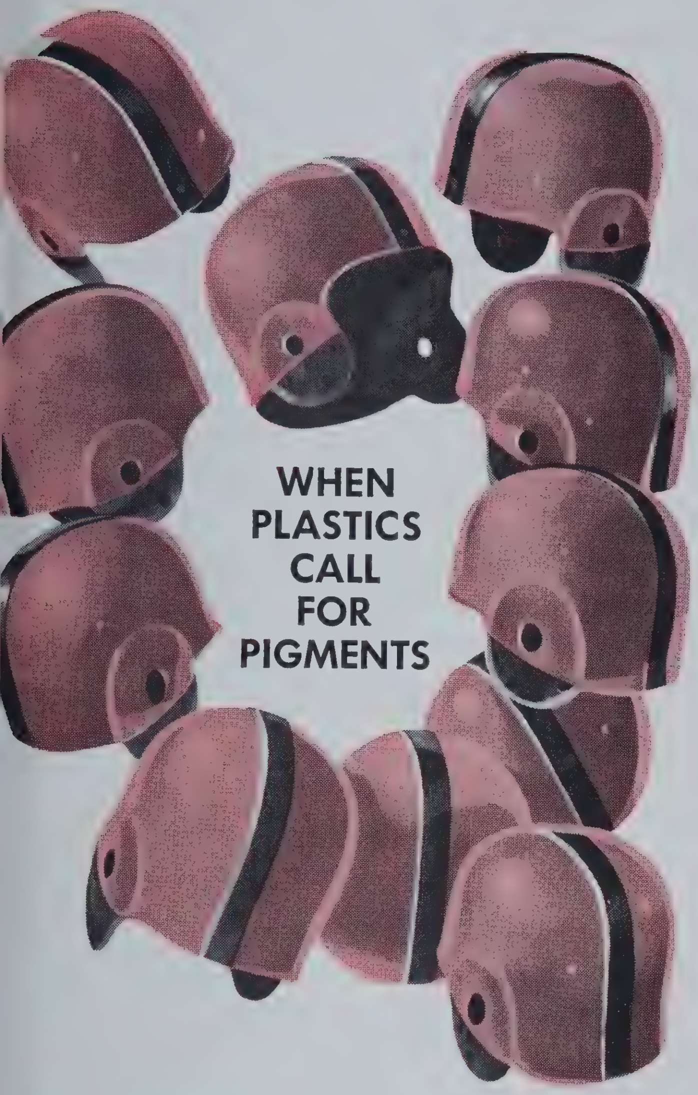
The solvent technology of vinyl resins also differs considerably from nitrocellulose. Solutions of high resin concentration tend to gel, as well as those in lean, thinner mixtures. These gels are not generally reversible, as are nitrocellulose gels, which merely require addition of solvent for the resin to be redissolved.

Ketones are the preferred solvents; however, nitroparaffins are also used as are some cyclic oxides. Aromatic hydrocarbons are generally preferred as the diluents. Alcohols are usually avoided in formulations containing standard vinyl copolymers.

Current developments

Developments in coating systems in which solvents are employed continue to arouse the interest of formulators. Of more recent vintage are the isocyanate lacquers. Basically, these coatings are formulated by dissolving a suitable polyalcohol and a polyisocyanate in suitable inert solvents. Inert solvents in this case are those which will not preferentially react with the isocyanates. The lower alcohols and basic solvents are not used, and solvents

(*Continued on page 369*)



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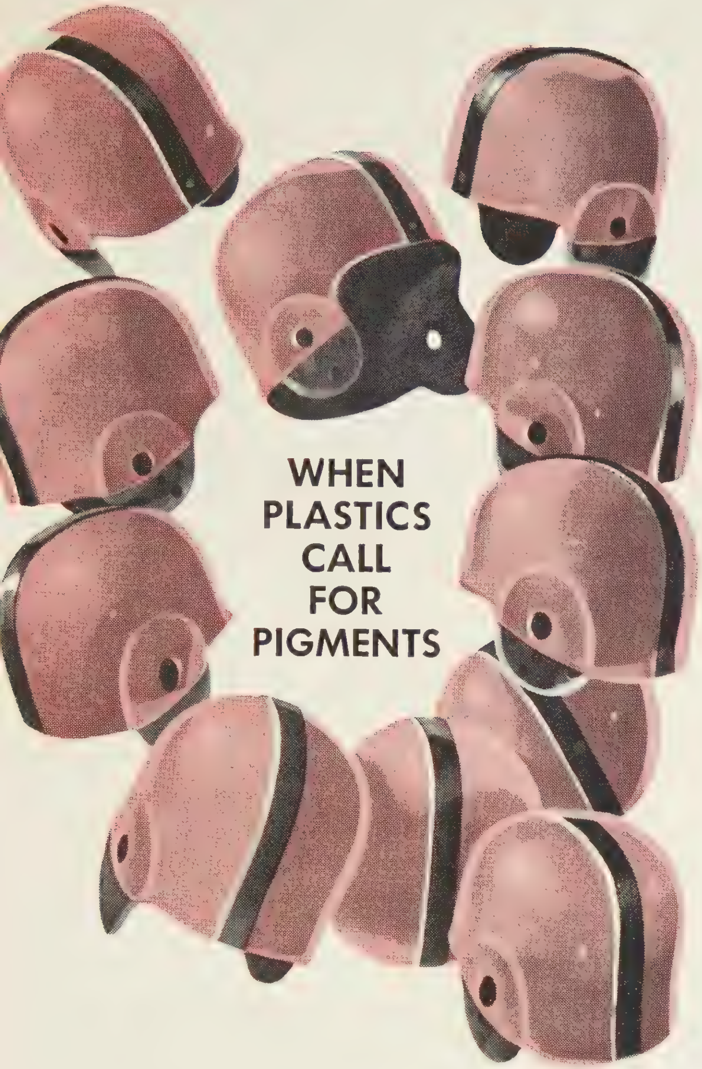

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containing reactive materials (water, amines, alcohols, glycols, or acids) should be avoided. Some of the pure esters such as ethyl, propyl, and butyl acetate find use as solvents in these coatings.

Urethane coatings have found wide acceptance as magnet wire enamel because of their solderability. Excellent chemical resistance, flexibility, hardness, abrasion resistance, and gloss retention has led to their use as marine, industrial, leather, and concrete coatings.

Much effort has been directed toward development of systems that would obviate the need for organic solvents as a means of controlling the fluidity of resinous materials. Various mechanical systems have been devised to permit the use of heat as a fluidizing agent, and emulsion technology, in which water is the fluidizing medium, has made great strides in development. However, many types of coating application would not be feasible except from an organic solvent medium. While the physical disadvantages of solvents (toxicity, flammability, etc.,) promote investigation of substitutes, the technological advantages gained by their use should permit them to maintain their commercial importance in the plastics industry for some time to come.

References

Consult the Subject Index for additional information on solvents. For sources of solvents, see Directory Index, p. 1078.

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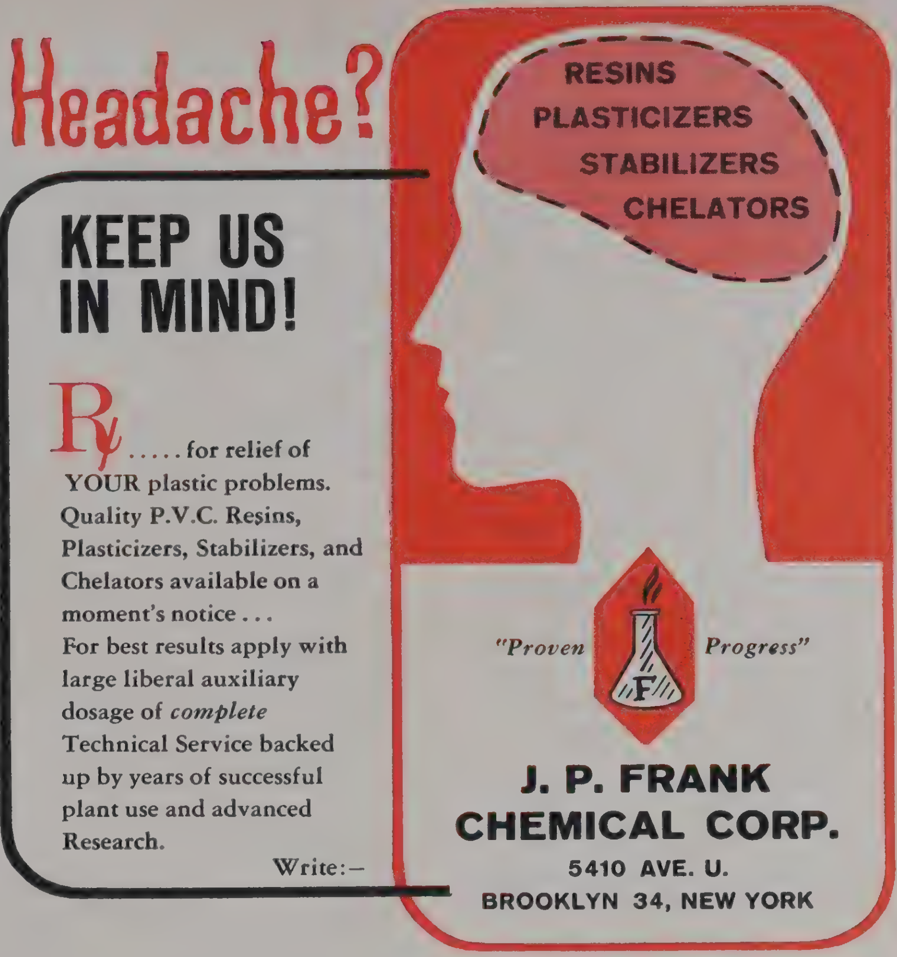
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Destaticizers

Static electricity charges cause articles molded of styrene to pick up dust when they are in production, on display, or in actual use in the home. Consequently, any device or compound which can reduce or eliminate the dust attraction of styrene is helpful.

Dust pickup due to static charges should not be confused with normal dust collection which will settle on any object regardless of its electrical charge.

The temporary low-cost destaticizers mentioned below are satisfactory in most cases for providing nearly complete destaticization at least until the end-product reaches the consumer.

Destaticizer requirements

To be completely satisfactory, a destaticizer should prevent the accumulation of electrostatic charge on the parts involved and be: 1) unaffected by normal handling; 2) preferably able to withstand moisture; 3) inert in its effect on various decorative materials; 4) relatively permanent in its destaticizing effect; 5) low in cost; 6) safe to handle; and 7) simple and economical to apply.

Temporary destaticizers

Destaticizers in this category provide only temporary protection against dust pickup. After a period of time, these coatings will lose their effect or wear off. Furthermore, should a damp rag be repeatedly used to wipe the treated pieces, the layer of destaticizing compounds will be removed.

These destaticizers are solutions which are usually applied by spraying, dipping, or wiping. Destaticizers in this class are among the most commonly used and are the least expensive, both from the standpoint of initial cost and cost of application. Where only temporary relief from dust pickup is required, they are very satisfactory and will prevent dust pickup during assembly operations and during display.

Destaticizers of this type are listed below.[1] Directions for their use can be obtained from the individual manufacturers.

Aerotex Softener H
American Cyanamid Co.
Textile Resin Dept.
Bound Brook, N.J.

Anstac-M
Chemical Development Corp.
Danvers, Mass.

Anti-Static 790L
Merix Chemical Co.
1021 E. 55th St.
Chicago 15, Ill.

Arquad 18 and Armacs T
Armour & Co.
Chicago, Ill.

Du Pont H-145
E. I. du Pont de Nemours & Co., Inc.
Wilmington, Del.

Lico
Lusta-Cite Industries, Inc.
225 West 28th St.
New York 1, N.Y.

LC-110
Raffi & Swanson Inc.
311 Eastern Ave.
Chelsea, Mass.

Parko Anti-Static
Park Chemical Co.
Detroit, Mich.

D-Stat-B
Roxbury Chemical Works, Inc.
2072 Smith St.
Centredale 11, R.I.

Standard Varnish No. 5605
Standard Varnish Works
2600 Richmond Terrace
Staten Island 3, N.Y.

Stati-Clean
Walco Products, Inc.
60 Franklin St.
East Orange, N.J.

Wilco
Wilco Co.
4425 Bandine Blvd.
Los Angeles, Calif.

A definite advantage of this class of destaticizers is their ease of combination with annealing baths.

A common household detergent, "Joy," is a satisfactory destaticizer when used in a concentration of one part detergent, one part glycerine, and 64 parts water.

A new means for the application of temporary destaticizers has been attempted in some plants and is now under evaluation. A solution is sprayed onto the die prior to the closing of the machine. The theory is that a destaticizing layer is thereby applied evenly to the molded object without the necessity of extra handling.

Semi-permanent destaticizers

Destaticizers of a semi-permanent nature will resist normal wiping with a damp rag. They are, however, soluble in soap and water. Their mechanical abrasion resistance is believed to be superior to the temporary type. This semi-permanent type includes the following:

Logostat R-2018
Bee Chemical Co.
13799 S. Avenue O
Chicago 33, Ill.

Merix 79
Merix Chemical Co.
1021 E. 55th St.
Chicago 15, Ill.

The manufacturer of Merix 79 claims that it is the only destaticizer which will destaticize both sides of the molded article (in parts up to ½ in. in thickness) by applying it to one side only.

Permanent destaticizers

Permanent type destaticizers insure a lasting effect through the entire normal life expectancy of the molded article. The cost of raw materials and of application are higher for this type of destaticizer. Where exceptionally good destaticization is required, it is suggested that the following source be investigated.[1]

Electrosol Process
Merrill J. Ainsworth
Northridge, Calif.

This process consists of dipping or spraying the molded article with each of two solutions, with an approximate 12 min. drying period between applications. This is reported by the manufacturer

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Information on antistatic materials for treatment of molded styrene and acrylic parts has been condensed for this article from various commercial bulletins. References were prepared by the editors.

[1] From Monsanto Chemical Co. literature.

to be a permanent type destaticizer under normal wearing conditions.

Logoquant
Bee Chemical Co.
Chicago, Ill.

This destaticizer is of a permanent nature but is not as efficient as some of the temporary types. It has a particular advantage in that it can be combined with colorants and used as a decorative lacquer.

Ionic static eliminators

Another means of attacking the static problem is through the use of radio-active elements or isotopes. These elements emit radiation which ionize the air in their immediate vicinity. The zone of ionized air acts as a conductor and bleeds off the troublesome electrostatic charge.

Both radium and polonium are available in forms suitable for commercial use in removing static charges. These are normally supplied in bar form for use in continuous processes. However, brushes with a polonium bar mounted on the ferrule and also compressed air or blow gun nozzles with polonium foil mounted in the air stream are available.

Radium has a considerably longer active life, but is more hazardous to handle and is not suitable for use in the molding shop. In a continuous process where the radium unit can be permanently located and guarded, it is to be desired. The polonium activated units emit only alpha radiation and are effective for only a distance of 1.6 in. so no safety hazard is involved, unless air within the danger range is inhaled.

The brush type eliminator (Omegatron Magic Brush) may be secured in widths from one to six inches. The dust is merely brushed from the molded article using the brush with the static eliminator in the forward position. If a slight charge remains, the brush is passed over the piece at about a height of 1 in. with the static eliminator facing downward.

The air gun eliminator (Alphatron Blow Gun) blows ionized air over the piece and removes the static charge. This can be done either upon removal from the die or immediately before any finishing operation.

Radio-active eliminators are not anti-static agents. They do not prevent the build-up of new static charges once the source of ionization has been removed.

Ionic static eliminators may be procured from[2]:

Alphatron Blow Guns and Omegatron Magic Brush
Reco Sales Co.
5630 Grand Central Terminal Bldg.
New York 17, N. Y.

Ionotron Static Eliminators
U.S. Radium Corp.
535 Pearl St.
New York 7, N. Y.

The methods described are the most common means for the destaticization of styrene plastic molded articles. In some instances it has also been found desirable to use various water-emulsion waxes such as Johnson's Wax or Parker's Wax. These are satisfactory destaticizers, but their use by molders is not too practical. This is due to the slow method of application which is involved with these waxes.

Integral destaticizing

An approach to the ideal of a styrene molding material which is inherently antistatic has been made by the introduction of Monsanto's Lustrex Lo-Stat, priced at 1¢/lb. higher than its counterpart in standard styrene. It is reported that an additive incorporated by the material maker gives molded surfaces that are sufficiently conductive to allow static charges to neutralize each other, however, it is not sufficiently conductive to adversely affect the electrical properties of moldings.

Anti-static for acrylics

For acrylic parts used indoors, anti-static coatings successfully prevent the accumulation of an electrostatic charge for periods of several months if the surface is not washed or wiped with a wet cloth. Between applications of the anti-static coating, the parts need only be dusted with a soft, clean cloth to maintain a good appearance.

For acrylic parts used outdoors, anti-static coatings can be applied before the parts are first installed to prevent static build-up when the parts are wiped down after installation. Successive coatings need not be applied unless the parts are frequently dry wiped since occasional rain and high humidity prevent static accumulations.

Anti-static solutions for coating acrylics include:

Anstac 2M
Chemical Development Corp.
Danvers, Mass.

Dextrol Lectrostat C
Dexter Chemical Corp.
819 Edgewater Rd.
New York 59, N. Y.

Like Magic
Merchandise Presentations, Inc.
206-208 E. 120th St.
New York, N.Y.

Negastat 502 (aerosol spray)
Phillips & Phillips Corp.
343 S. Dearborn Ave.
Chicago 4, Ill.

Neutrox-X
Nykel Products Co., Inc.
P. O. Box 272
Red Bank, N. J.

Nudeea #1306
Haas Miller Corp.
4th & Bristol Sts.
Philadelphia 40, Pa.

In use, these anti-static coatings should be applied in a very thin and uniform layer. If beads appear as it is applied, the coat is too thick and the excess should be removed with another cloth. Allow the coating to dry, then bring to a high gloss employing a soft cloth.

References

Consult the Subject Index for additional information on destaticizers. For sources of antistatic agents, consult the Directory Index, p. 1078.

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[2] Recommended in Monsanto Chemical Co. literature.

Ultra-violet absorbers

By H. W. Zussman*

for stabilization of materials and screening purposes

Ultra-violet absorbers are used in plastics principally for stabilization of polymer or secondary ingredients against photo-catalyzed deterioration, and for screening out ultra-violet light in glazing, packaging materials, and coatings. Other types of ultra-violet absorbers used include fluorescent agents capable of masking yellowness in plastics by converting absorbed ultra-violet energy into visible bluish light; and photosensitizers, which are unstable absorbers that convert readily to peroxides or free radicals, transmitting absorbed energy directly to the substrate, thus promoting polymerization or cross-linking. This article will cover only recent developments in ultra-violet absorbers offered for stabilization of plastics materials and screening purposes.

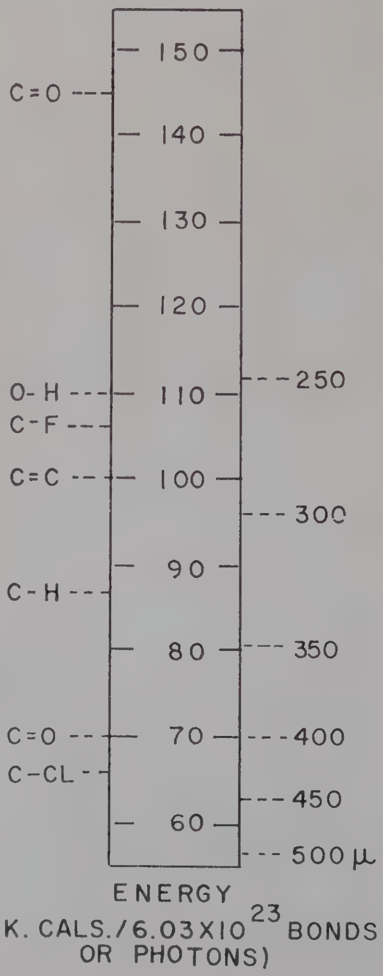
The deterioration of plastics on light exposure is usually (but not always) attributed to radiation below 400 µ. The ultra-violet component of sunlight at sea level represents about 6% of the total available energy; this varies, however, with the altitude and with the height of the sun in the sky, since the earth's atmosphere itself acts as an ultra-violet filter. Domestic fluorescent lights have a lower ultra-violet content, but their effect on plastics is accentuated by proximity. The solar spectrum at sea level does not extend below 285 µ; exposure to lower radiation is still uncommon (germicidal lamps, high altitude aviation, missiles, arcs) but may be expected to increase.

Potency of radiation

It is sometimes difficult to appreciate the potency of ultra-violet radiation until one recalls how quickly a painful sunburn may be acquired and considers that the radiation responsible (290 to 310 µ) represents less than 0.2% of the total solar radiation. The lower the wavelength of the incident light, the higher the energy content per photon and the more damaging its effect potentially; to produce chemical change in a material, however, this energy must first be absorbed. Plastics differ appreciably in their ultra-violet absorbing properties, but none are completely transparent in the 300 to 400 µ range and all absorb significantly at 300 µ and lower. Once radiant energy is absorbed, the likelihood of chemical change will depend on the stability of chemical bondings in the polymer. The energy required to disrupt some typical bonds and the energy content of ultra-violet radiation of various wavelengths is indicated in Fig. 1 below.

In practice, the deteriorative effect of light is usually enhanced by the presence of oxygen, moisture, and heat. In many cases, the deterioration is properly photo-oxidation (polyamides, polystyrene, polyolefins). Color changes are frequently associated not only with the polymer but with impurities such as residual styrene monomer in polystyrene (8)[1] or traces of iron in polyesters (6), or with sensitive additives such as plasticizers (tricresyl phosphate) or dye-stuffs. Considering the variety of photo-catalyzed deterioration possible, it is not surprising that many anti-oxidants and thermal stabilizers provide some degree of light protection. Most promising, however, are the ultra-violet absorbers which, in essence, compete with the plastic substrate for incident ultra-violet light, dissipating this radiation harmlessly as vibrational energy. Such products have proved useful in a wide variety of applications (3, 4, 6, 10, 12, 14, 15, 16); not appreciably benefited to date are the polyamides, the polyurethanes, and many of the useful dyestuffs, which are sensitive largely to visible rather than to ultra-violet radiation.

FIG. 1



Requirements of absorbers

Commercial ultra-violet absorbers generally meet the following common requirements: absence of significant color, initially and on aging; good compatibility; inertness to other additives, to processing, and to weathering. They must have high ultra-violet absorbtivity and must themselves be stable to ultra-violet radiation. Among the more commonly used products are:

Phenyl salicylate (Salol)

Tertiary butyl phenyl salicylate

2, 4-dihydroxybenzophenone (Uvinul 400)

2, 4-dibenzoyl resorcinol

2-hydroxy-4-methoxy benzophenone (Cyasorb 9)

2, 2'-dihydroxy-4-methoxybenzophenone (Cyasorb 24)

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[1] Numbers in parentheses link to references on p. 377.

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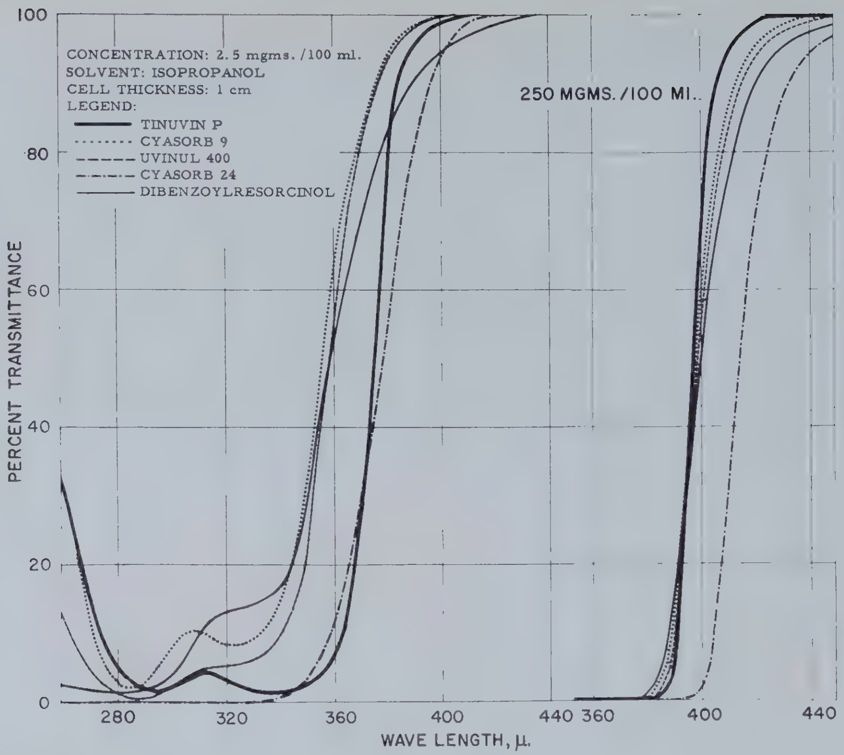

FIG. 2

2, 2'-dihydroxy-4-octyloxybenzophenone

2, 2'-dihydroxy-4, 4'-dimethoxybenzophenone (Uvinul D49)

Alkylated 2-hydroxyphenyl benzotriazole (Tinuvin P)

All of these products, with the exception of the last, possess a phenolic hydroxyl close to—actually chelated with—a carbonyl (C=O); less well characterized, but also in this group are Permyl B100 and Nopcosorb NLZ. Tinuvin P, likewise, contains a hydroxyl but chelated with nitrogen in a triazole ring. Of the various noncommercial compounds noted in the patent literature, thiazolidone derivatives (16 m) are worth mentioning, since one of these has been reported very effective in polyethylene (14).

The transmission curves of several ultra-violet absorbers at 0.0025 and 0.25% in isopropanol are compared in Fig. 2. Ideally, an ultra-violet absorber should transmit 0% up to 400 μ and 100% above 400 μ, completely screening out all ultra-violet light, yet with complete freedom from color; obviously, some compromise is necessary. The closest approach to a 90° cut-off is offered by the hydroxyphenyl benzotriazole derivatives. While the absorption spectrum is characteristic of the chelate grouping, it may be modified by substituents elsewhere in the molecule, and the absorption spectrum may be shifted with concentration, thickness of the absorbing layer, and the refractive index or polarity of the substrate; molecular association—between absorber molecules, or between absorber and substrate—does not always permit accurate prediction of such relationships. Absorption characteristics will also be affected by ionization of the phenolic group and by formation of complexes with inorganic cations; such shifts may usually be corrected by the addition of acidic materials such as stearic acid. Ester-containing absorbers show a significant increase in absorption and shift to the visible on brief ultra-violet exposure; in the case of phenyl salicylate, the shift is as much as 40 μ (10).

Currently available absorbers are all more or less comparable in light stability, although they differ in solubility, ease of sublimation at elevated temperatures, and sensitivity to oxidation. The benzophenones are more readily reduced than the hydroxyphenyl benzotriazoles and will also react with amines. Hydroxyphenyl benzotriazoles exhibit antioxidant and heat stabilizing properties in some formulations. While all of the commercial ultra-violet absorbers have low toxicity, the salicylates have the advantage of historical experience.

How absorbers are used

Absorbers may be incorporated into polymers in the same way as colors; they may frequently be added to the monomer or prepolymer, sometimes with improvement of the polymer; copolymerizable vinyl salicylates have recently been described (16). Where it is convenient, the incorporation of a given amount of absorber in a coating or in the top layer of a laminated structure is more efficient than dispersing the absorber throughout the mass of the plastic. Thin films and coatings require a much higher concentration of ultra-violet absorber (1 to 8%) than do thick structures (0.2 to 1%). Pigmented and opaque articles generally require less absorber than clears (11). Advantages are claimed for mixtures of ultra-violet absorbers (16g).

A convenient method for evaluating the potential usefulness of an ultra-violet absorber is to expose the test material partially covered with a clear sheet containing the test compound. In this way, it is possible to demonstrate that radiation above 400 μ is largely responsible for the deterioration of nylon (5). If the absorber is effective under these conditions, it will certainly be useful as a coating. Effectiveness in the resin will depend on overall compatibility and inertness; with polyolefins, for example, poor performance is generally due to poor solubility and blooming.

Testing procedures

The most serious problem in evaluation is the need for devising completely reliable accelerated testing procedures (9, 13); basically, this problem revolves around the availability of suitable high-output artificial light sources, although other factors in weathering (notably oxygen supply and cyclic temperature variations) require more careful attention. The differences in emission characteristics of some light sources are great: promising, but not without inconvenience, is the water-encased xenon lamp, whose spectral

(Continued on p. 377)

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Trogamid	Rods and tubes from **polyamide**
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Mipolam	**Extrusion materials:** Granulated Polyvinyl Chloride with plasticizer for insulation of cables and conduits
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Trovidur	**Unplasticized polyvinyl chloride** in the form of foils, sheet blocks, tubes (also with fittings), rods, hollow rods, profile welding rods, for application in the chemical und allie industries
Trolen H	**Low-pressure polyethylene** (hard polyethylene) in the for of sheets, foils, blocks, tubes, welding rods
Mipolam	**Plasticized polyvinyl chloride:** Smooth, embossed an printed foils for fancy goods, for rainproof and protectiv clothing, foils for book binding purposes, embossed foi for leather goods, office equipment, upholstery, high lustr polished sheet
Mipolette	Smooth, embossed, and printed foils for decoration
Mipofix	Smooth, embossed, or printed adhesive foil
Librafol	Book binding material of flexible polyvinyl chloride foi paper backed
Libradur	Rigid polyvinyl chloride sheets as stiffening material f briefcases and book binding purposes
Mipolam	Plasticized polivinyl chloride foils and sheets for technic applications: sealings, linings, protective panelling profile for technical purposes, amongst others for application automotive engineering, acid.-resisting hoses
Trolen	**High-pressure polyethylene** with and without addition polyisobutylene: foils, sheets, tubes, and welding rods
Trovitherm	**Polyvinyl Chloride** packaging foils types G and UG.
Ultrapas	**Resin-bonded laminated sheets** for decoration and interi furnishing in various shades and patterns, dimension 2440 x 1220 (8 ft x 4 ft) and 2800 x 1220 mm (9 ft x 4 ft).
Mipolam	**For covering of floors,** tables, and doors, 2 and 3 mm thi
Mipolam	**Stair-nosing and skirting profiles,** handrails for baniste etc., tube covering, profiles for shopwindows and caseme windows
Tronex	Endles corrugated polyester sheeting for roofing purpos balcony linings, partition walls etc.

emission most closely resembles sunlight.

Performance requirements for ultra-violet absorbers for use as filters are essentially the same as for stabilizers, although frequently some yellow color is acceptable. For food packaging use, non-toxicity and/or sufficiently low solubility to prevent extraction are necessary. Ultra-violet absorbers satisfactory as stabilizers are otherwise satisfactory for use as filters.

If the performance of available ultra-violet absorbers is less than ideal, it might be remembered that this field is relatively new; a recent market survey (1) predicts a tenfold expansion in the use of ultra-violet absorbers by 1965.

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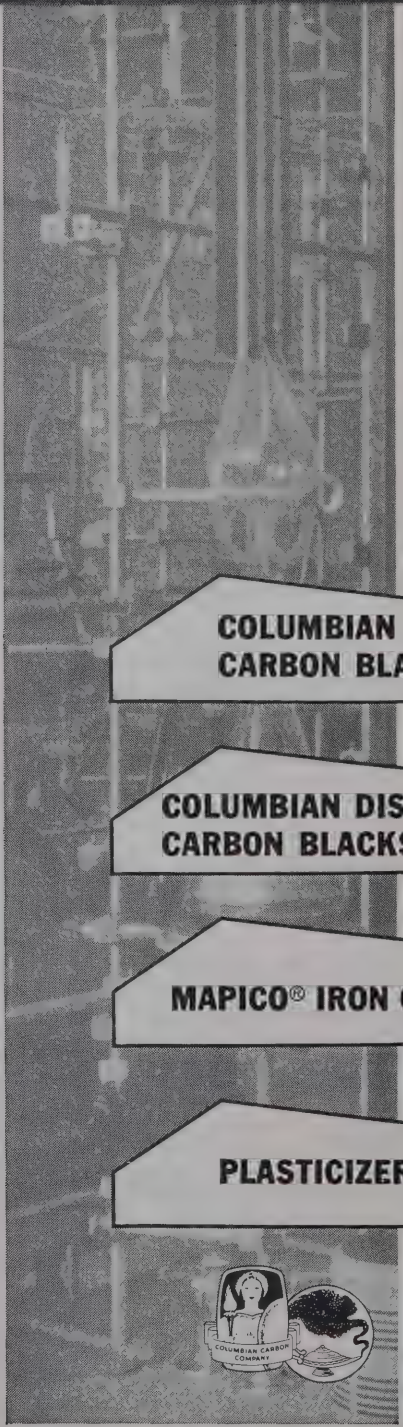

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Isomeric mixture of approximately 80% of 2,4-tolylene diisocyanate and 20% of 2,6-tolylene diisocyanate.

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- **EpoxyGen** 80 (regular grade) having a *guaranteed* minimum 85% epoxy content.*
- **EpoxyGen** 90 (premium grade) having a *guaranteed* minimum 90% epoxy content.*

EpoxyGen is guaranteed to meet the following specifications:

Specifications	**EpoxyGen 80** (Regular Grade)	**EpoxyGen 90** (Premium Grade)
Epoxy Content*	85% min.	90% min.
Oxirane Content, % oxygen	6.4% min.	6.8% min.
Iodine Value (Wijs)	4.5 max.	2.0 max.
Color (Gardner 1933)	1 max.	1 max.
Acid Value	0.3 max.	0.2 max.
Viscosity (Gardner-Holdt)	Q max. (i.e. 4.4 poises at 25°C.)	P max. (i.e. 4.0 poises at 25°C.)

**% of theoretical.—Basis: Iodine value of starting oil = 130*

EpoxyGen also has the following typical qualities:

	EpoxyGen 80	**EpoxyGen 90**
Epoxy Content*	87%	91%
Oxirane Content, % Oxygen	6.6	6.9
Iodine Value (Wijs)	3.4	1.7
Color (% transmission)	82%	88%
Acid Value	0.1	0.1
Saponification Value	182	183
Viscosity, Poises at 25°C.	3.9	3.9
Specific Gravity, at 25°C./25°C.	0.996	0.996
Pounds per Gallon, at 25°C.	8.3	8.3
Molecular Weight (approx.)	1000	1000

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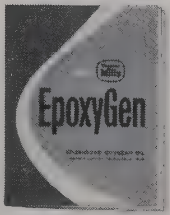

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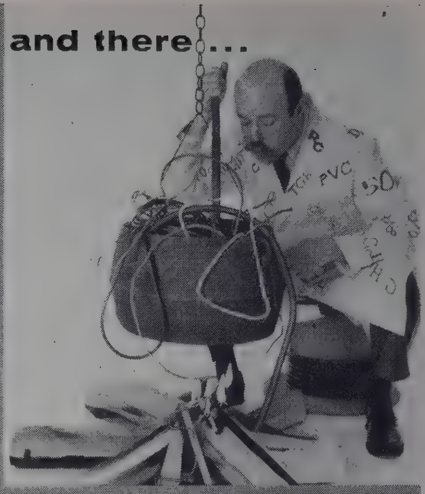

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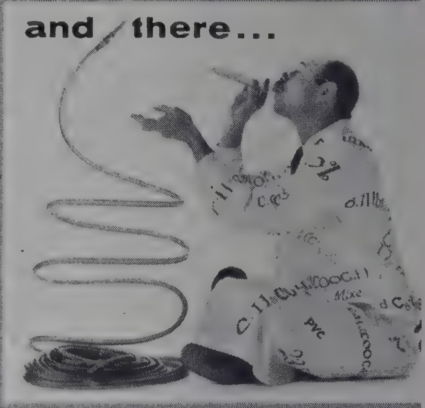

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CADOX BDP	50% benzoyl peroxide with dibutyl phthalate
CADOX BSA	95% benzoyl peroxide fine powder with stearic acid
CADOX BSD	50% benzoyl peroxide finely milled with silicone fluid.
CADOX BTP	50% benzoyl peroxide with tricresyl phosphate
CADOX B 160	55% benzoyl peroxide with butyl benzyl phthalate
CADOX MDP	60% methyl ethyl ketone peroxide in dimethyl phthalate

PRODUCT NAME	DESCRIPTION
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CADOX BSG	50% benzoyl peroxide finely milled with silicone fluid
CADOX TDP	50% 2,4 — dichlorobenzoyl peroxide with dibutyl phthalate
CADOX TS 40 & 50	2,4 — dichlorobenzoyl peroxide with silicone fluid
CUMENE HYDROPEROXIDE	Assay — 73%
DIISOPROPYL BENZENE HYDROPEROXIDE	Assay — 53%
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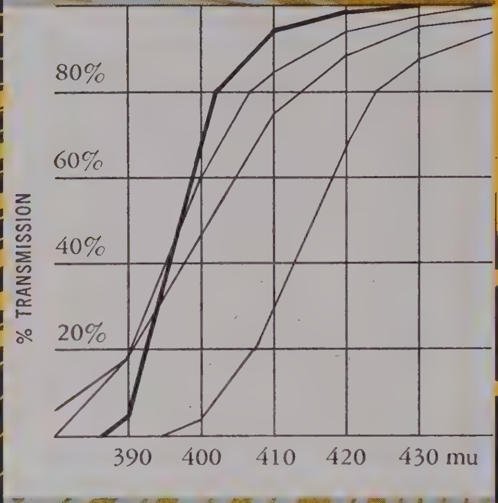

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benzotriazole ultraviolet absorber

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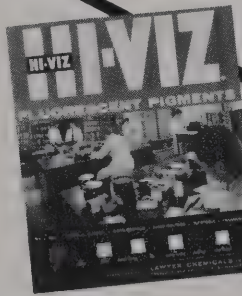

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Nacromer completely overcomes the waxy, dull finish of polyethylene, providing a high gloss and transparency impossible to achieve any other way.

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Nacromer endows this plastic with unequalled richness by creating a high pearly lustre of exceptional depth.

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LUPERCO® ATC Benzoyl Peroxide with tricresyl phosphate	Thick Paste	50%	Catalyst for polyester resins at intermediate and low temperatures.
LUPERCO® CDB 2,4 Dichlorobenzoyl Peroxide with dibutyl phthalate	Thick Paste	50%	Catalyst for vinyl type monomers and polyester resins.
ALPEROX® C Lauroyl Peroxide	Soft Granular	95%	Catalyst for vinyl type monomers and olefins.
ACETYL PEROXIDE 25% SOLUTION in dimethyl phthalate	Liquid	25%	A liquid, highly reactive, low molecular weight, aliphatic polymerization catalyst.
LUPERSOL® MMO Caprylyl Peroxide in mineral oil	Liquid	50%	Catalyst for vinyl type monomers where mineral oil is the preferred diluent.
HYDROXYHEPTYL PEROXIDE	Fine Powder	95%	Catalyst for intermediate and low temperature curing of polyester resins.
LUPERCO® JDB-50-T Cyclohexanone Peroxides with dibutyl phthalate	Thick Paste	45%	Catalyst for vinyl type monomers and for room temperature curing of polyester resins.
LUPEROX® #6 Ketone Peroxide #6	Fine Powder	90%	Catalyst for fast room temperature curing of polyester resins.
LUPERSOL® DDM Methyl Ethyl Ketone Peroxide in dimethyl phthalate	Liquid	60%	Catalyst for room temperature curing of polyester resins.
LUPERSOL® #7 t-Butyl Peracetate in benzene	Liquid	75%	Catalyst for vinyl type monomers and olefins.
LUPERSOL® #8 t-Butyl Peroxyisobutyrate in benzene	Liquid	75%	Catalyst for vinyl type monomers and olefins.
LUPERSOL® KDB Di-t-Butyl Diperphthalate in dibutyl phthalate	Liquid	50%	Catalyst for intermediate and low temperature curing of polyester resins.
t-BUTYL PERBENZOATE	Liquid	95%	Catalyst for vinyl type monomers and for high temperature curing of polyester resins.
Di-t-BUTYL PEROXIDE	Liquid	97%	High temperature catalyst for silicone resins, styrenation of alkyds and epoxy resins.
LUPEROX® 2,5-2,5 2,5-Dimethylhexane-2,5-Dihydroperoxide	Fine Powder	90%	High temperature catalyst for polyester premix compounds and silicone resins.
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Dibutyl Sebacate	0.935	7.9	Vinyl Resins, Cellulose Acetobutyrate, Synthetic Rubbers, Rubber Hydrochloride, Polystyrene, Polymethyl Methacrylate.	Low Temp. Flexibility, Excellent Aging Qualities, Non-toxic
Diisooctyl Sebacate	0.914	17.2	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Low Temp. Flexibility, Low Volatility
Dimethyl Sebacate	0.986*	3.54 @ 30°C	Vinyl Resins, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate, Acrylic Resins.	High Solvency and Efficiency, Wide Compatibility
Dioctyl Sebacate	0.913	17.4	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Low Temp. Flexibility, Low Volatility, Good Electricals
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Diisodecyl Phthalate	0.965	65	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Cellulose Nitrate, Cellulose Acetobutyrate, Chlorinated Rubbers.	Low Volatility, Good Electricals
Dioctyl Phthalate	0.983	57	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Highly Compatible, Good Flexibility
Isooctyldecyl Phthalate	0.973	68	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Improved Flexibility, Permanence, Good Electricals
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®Harflex 330	1.081	2270 @ 100°F/cs	Vinyl Chloride Polymers and Copolymers, Synthetic Rubbers, Nitrocellulose, Cellulose Acetobutyrate.	Non-Migratory, Permanence, Highly Compatible
®Harflex 375	1.061	45000 @ 100°F/cs	Vinyl Chloride Polymers and Copolymers, Nitrocellulose, Synthetic Rubbers.	Extreme Permanence
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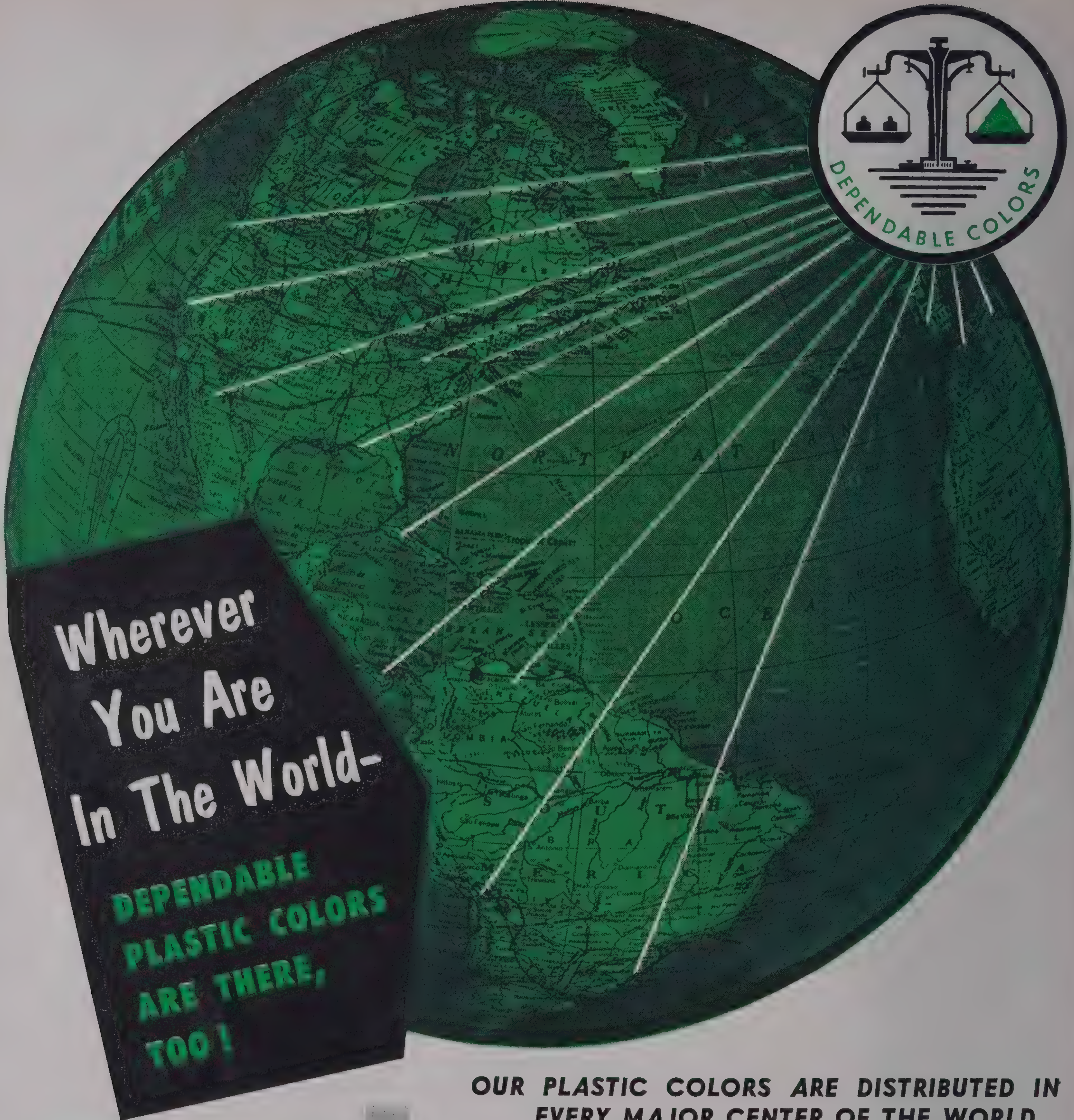
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Now...longer life expectancy for vinyls

Two new polymeric plasticizers overcome the old limitations on vinyl durability, permanence, and heat resistance—without the processing and handling problems of early polymeric types

ELASTEX® Plasticizers 36-R and 37-R, two new polymeric plasticizers for use as primary agents or in blends with monomeric types, now make possible improvements in a broad range of end-product properties—longer life, reduced shrinkage, lower volatility, less migration (in vinyl tile), greater resistance to heat and solvents.

"ELASTEX" 37-R Plasticizer is a high molecular weight material designed for vinyl compounding. It enables vinyl products to withstand high temperatures and remain practically unaffected by kerosene, oil and soapy water. Suggested applications: cable jackets, paper coatings, appliance gaskets, high-grade upholstery sheeting.

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New Process Super Ground 96%—used for the most exacting conditions where a superfine powder is required.

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% Formaldehyde	55 Min.	40 Min.
% Water	12 Max.	8.5 Max.
% Methanol	33 Min.	—
% N-Butanol	—	51.5 Min.

NEW UREA FORMALDEHYDE 26-59

Here is a clear, stable solution of urea in formaldehyde. Du Pont UF 26-59 has a low viscosity and is made with high-quality urea. Du Pont research has produced a product of such uniformity and purity that it can help you reduce or eliminate troublesome side reactions in your finished product.

Composition of Urea Formaldehyde*

% Formaldehyde	59 Min.
% Urea	26 Min.
% Water	15 Max.

**This is a specification.*

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Du Pont plants are strategically located to deliver shipments on time, *every time.*

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- Paraformaldehyde Powder 96%
- Paraformaldehyde Super Ground 96%
- Methanol Formaldehyde 33-55
- N-Butanol Formaldehyde 51-40
- Urea Formaldehyde 26-59
- 50% (by weight) Formaldehyde L.M.
- 45% (by weight) Formaldehyde L.M.
- 37% (by weight) Formaldehyde L.M.
- 37% (by weight) Formaldehyde U. S. Pharmacopoeia
- Hexamethylenetetramine Tech., powder or granular
- Hexamethylenetetramine Tech., FF (with anti-caking agent), powder or granular

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• Du Pont's new Sales Technical Laboratory houses equipment for product demonstration and customer service. New product applications and processes are researched here.

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The new Electrochemicals Sales Technical Laboratory has extensive facilities for the development of new product applications and processes involving chlorine, vinyl, sodium and peroxygen products . . . plus plant-sized equipment for product demonstration and the study of industrial problems under actual production conditions. Call your Du Pont Representative; he'll be glad to discuss any problem with you.

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For more information on any of the Electrochemicals Department's products for plastics listed on these pages—and how any of these products can fit into your operation . . . contact your nearest Du Pont district office or write address below. No obligation, of course.

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The Du Pont Electrochemicals Department has a wide range of additional chemicals useful in the manufacture of fine plastics:

CHLOROFORM—Solvent for cellulose acetate (used in film coatings).

ELVACET® POLYVINYL ACETATE EMULSION—Binder; protective coating; asphalt-proof base coat for linoleums.

ELVANOL® POLYVINYL ALCOHOL—Binder; protective coating; emulsifying agent; thermosetting resin modifier; thickener for latices.

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METHYL CHLORIDE—Synthesis of silicones.

SILVER PREPARATIONS—Printed circuits.

SODIUM CYANIDE 96%—Used in manufacture of acrylic resins.

SODIUM PERBORATE TETRAHYDRATE—Polymerization catalyst.

SODIUM PEROXIDE—Polymerization catalyst.

TRICHLORETHYLENE—Solvent for silicone resins; used in manufacture of polyvinyl-acetate glues.

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STABILIZERS. 41-page handbook discusses solutions to problems encountered in stabilizing polyvinyl chloride resins. Presents recommendations for rigids, flexible vinyls, plastisols and organisols, expanded vinyls, and homogeneous and asbestos tile. Ferro Chemical Corp.

All the booklets described here—plus hundreds and hundreds of others—are yours for the asking, entirely without cost or obligation.

Just turn to the Manufacturers' Literature Section (immediately preceding the Buyers' Directory), circle the numbers you want, fill in the reply post card, and mail. No postage is needed.

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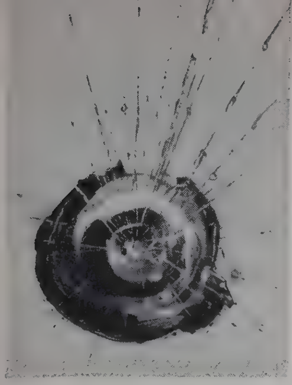
DECORATIVE VINYL SHEETING. 16-page illustrated brochure discusses features and fabricating techniques of this company's semi-rigid vinyl sheeting, available in colors and various finishes for bonding to steel and non-ferrous metals. Applications include desk and table tops, luggage, seats, kitchen cabinets, advertising displays, etc. Columbus Coated Fabrics Corp.

EXTRUDERS, BLOW MOLDING MACHINES. 24-page illustrated brochure describes lines of German built extruders and special extrusion heads for specific production; also blow molding machines for the manufacture of bottles, dolls, toys, household articles, etc. Barclay Industries.

NYLON RESINS. Illustrated 56-page booklet discusses the properties, design possibilities, applications, and advantages of "Zytel" nylon resins. Includes injection molding, extrusion, and wire coating techniques. E. I. du Pont de Nemours & Co., Inc.



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FILM, SHEETING, AND SHAPES

Survey of film and sheeting

Today, virtually all thermoplastics are being used in varying amounts in the films (under 10 mils thick) and sheeting (over 10 mils thick) industry—and the volume continues to grow. As a guide to the many materials available, the following reports have been prepared by the various material suppliers. For more specific details on the physical properties of the various types of plastics films, consult the Films Chart, p. 532.

Vinyl film and sheet

Practically all vinyl film and sheeting sold commercially today is produced by calendering, casting, or extrusion. (The term *vinyl* as used in this article covers both polymers and copolymers, including polyvinyl chloride and polyvinyl chloride-acetate copolymers.)

As for surface finishes, plasticized vinyl film and sheeting is supplied in a matte or glossy finish which is imparted by the calender roll or by subsequent finishing rolls. Various decorative finishes such as taffeta or linen can also be obtained with special embossing rolls. By press lamination it is possible to supply matte or highly polished rigid film and sheeting up to ½-in. thick. Both plasticized and rigid vinyl film and sheeting are readily embossed during calendering or in subsequent operations.

Plasticized calendered vinyl film and sheeting: Following are the general characteristics of this class of materials.

General properties: Plasticized calendered vinyl film and sheeting are characterized by moderate tensile strength, high elongation, good tear strength, low water absorption, and moderately good chemical resistance. For specific applications, one or two of these properties may be maximized through special formulations.

Processing: Plasticized vinyl films can be sewn, heat-sealed, or electronically sealed; special films can be coated with pressure-sensitive adhesives. Sheetings can also be heat-sealed or electronically sealed, and special formulations can be coated with pressure-sensitive adhesives. They can also be formed easily and accurately by conventional thermoforming techniques.

Applications: Film—raincoats; shower curtains; window shades; draperies; table covers; wall covering; closet accessories; inflatable toys; baby pants; and protective covers. Sheeting—upholstery; swimming pool liners; women's handbags; luggage; clear auto seat covers; convertible rear windows; and inflatable toys. Laminates—construction and ball park tarpaulins; pool covers; boat covers; beach umbrellas; automobile upholstery; etc.

Colors available: Plasticized vinyl films and sheetings have a wide range of transparent, translucent, and opaque colors.

Rigid vinyl calendered film and sheeting: Following are the general characteristics of the rigid unplasticized materials (including those that contain from 87 to 97% resin, as well as straight PVC resins).

General properties: Rigid vinyl film and sheeting have good dimensional stability, high tensile strength, low water absorption, good-to-excellent chemical resistance, and flame-resistance. Special sheeting formulations also impart excellent light stability. Straight PVC film has, additionally, higher heat-distortion and chemical resistance.

Processing: The rigids can be cut, machined, and punched into such intricate articles as drafting instruments; they can be vacuum formed into signs, displays, relief maps, lighting panels; they can also be sealed to another rigid vinyl or to other plastics with solvents or cements; they can be overlaminated.

Applications: Overlaminating printed credit cards; place mats; wall coverings; and decorative laminates. Forming material for signs, displays, lighting panels (formed or corrugated), relief maps, and toys. Rigid sheeting for recording disks; shower doors; industrial safety windows; lampshades; drafting instruments; credit card and playing card core stock; and lining for industrial tanks. Straight PVC rigid film as tape bases in packaging, and in electrical insulation applications requiring chemical resistance.

Available colors: The range of translucent and opaque colors available for the rigid vinyls is virtually unlimited. Degrees of transparency, however, become limited with increasing thickness.

Plasticized and rigid cast vinyl film has the following special characteristics to offer:

General properties: Cast vinyl

Section on Vinyls prepared by Union Carbide Plastics, Div. of Union Carbide Corp., Bound Brook, N. J.

Polypropylene film is now under investigation (*Proplene*, Ludlow Papers, Inc., Plastics Div.). Reportedly, the film exhibits the following desirable characteristics: density—0.90; tensile strength—7800 p.s.i. (machine direction), 6600 p.s.i. (transverse direction); tear strength—40 g./mil (machine direction) and 329 g./mil (transverse direction); impact strength at 72° F.—0.22 ft. lb.; heat sealing range—325-400° F.; low temperature flexibility—80° F.; water vapor transmission—0.65 g./100 sq. in./mil/24 hr. at 100° F. and 90% R.H.; haze—3%; and gloss (photovolts)—96. On the basis of its special properties, several applications are beginning to open up for the material, primarily in the packaging field. For example the film can be formed for skin or blister packaging and, because of its good strength, tear resistance, and greaseproofness, is especially recommended for packaging sharp, pointed, or oily materials. Because of its unusually high dielectric strength, approximately 4500 v./mil, the film holds potential as a high dielectric tape.

• • • •

Film based on nylon 6 materials and processed (into flat film only) by cast film processing (*Caplene*, Ludlow Papers, Inc.) holds potential in the packaging field. The film can be converted into pouches, bags, or overwrap and appears especially useful in packaging such items as hardware, abrasive stones, etc., where its strength and abrasion resistance would play an important role. Its greaseproofness should also make it ideal for packing nonedible fat, grease, and oil products or as a lining for drums, cans, boxes, and unsupported pouches. Skin or blister packaging, windows for folding cartons, or packages for items that have to be sterilized by autoclaving are other possibilities. Flexible textured sheetings made from foamed polyolefins (*Metafoam*) are available from the same company and show excellent potential for the food packaging field where their thermoformability, insulation values, heat sealability, and abrasion resistance can play an important role.

• • • •

A laminating and surfacing polyester film (*Videne A*, The Goodyear Tire & Rubber Co.) which can be heat- and pressure-bonded to practically any surface, e.g., metals, wood, fabrics, papers, etc., as a protective and decorative finish is available. The film can also be stretch-laminated, without adhesives, to web form materials, such as paper, foil, or fabric at temperature above 250° F. It has a wide range of service temperatures (—40 to 200° F.), high electrical insulating properties, excellent chemical and solvent resistance, and excellent grease resistance. Possible applications are in the fields of wall coverings, appliances, automotive, building materials, etc. *Videne TC* is a heat-shrinkable packaging film—an oriented polyester with a thermoplastic coating on both faces. It is most practical for skin-tight packaging of smoked and processed meats, fresh or quick-frozen poultry, and similar applications.

• • • •

A heat-sealable polyester film (at temperature of from 300 to 400° F. at 20 to 60 p.s.i. pressure) is available (*Scotchpak*, Minnesota Mining and Mfg. Co.). The film is dimensionally stable and flexible from —70° F. to 240° F., has tensile strength as high as 10,000 p.s.i., burst strength of from 32 to 50 p.s.i., low water vapor permeability, low gas penetration, and resists most chemicals and solvents. It can be used for packaging product samples, viscous liquids, metal parts (either dry or in oil), fresh meats (that can be sterilized by radiation and sold without refrigeration), pre-cooked foods, chemicals, etc.

• • • •

Chill roll polyethylene film is being actively investigated by several companies. Interest in the new film has grown rapidly, primarily because its clarity enables it to compete for new packaging markets. The term "chill roll" is derived from the fact that, in extrusion, the film is passed over a chilled, highly polished roller to give it greater clarity. Chill roll casting is also regarded as one of the best methods for producing film from other thermoplastics such as nylon and polypropylene.

• • • •

Use of 1-mil polyester film (*Mylar*, Du Pont), type A, to replace certain materials in building wire and service entrance cable has been approved by Underwriters' Laboratories. In the building wire application, the film can be used over previously vulcanized rubber insulation and under an asphalt-pitch impregnated cotton braid in cables No. 8 AWG and larger. In the service entrance cable application, approval has been granted for use of polyester film over the stranded neutral conductors and under the outer braid when type RHW insulation is used on the insulated conductor.

• • • •

Drafting materials based on polyester film (*Mylar*, Du Pont) are now being offered by several manufacturers. In contrast to conventional drawing materials, polyester film withstands wear and abuse without tearing and fraying, does not turn yellow, and lasts indefinitely.

• • • •

Extruded sheets (Cadillac Plastic & Chemical Co.) of new impact modified acrylic resin (*Implex A*, Rohm & Haas Co.) are used in housings, tote trays, machine parts, table tops, luggage, and parts exposed to continuous or intermittent contact with water.

• • • •

A versatile wrapping machine (Battle Creek Packaging Machines, Inc.) weld-seals unsupported polyethylene and other plastics films at speeds up to 75 packages per minute. The new process, called thermo-pad sealing, combines heat and artificial refrigeration.

• • • •

A pressure-sensitive, paper-backed polyethylene tape (*Ger-*

Pak Miracle Tape, Gering Products, Inc.) solves problems of joining and patching polyethylene film used in agriculture and construction.

• • • •

Sheets of high-density polyethylene (*Midlon LP,* Midwest Plastic Products Co.) have high crystallinity, high tensile strength, high softening temperature, high stability, and low permeability.

• • • •

A new 4-mil film (*FRF,* Owens-Corning Fiberglas Corp.) is composed of a layer of fibrous glass scrim laminated between two layers of polyethylene film. It is produced on equipment similar to that used for polyethylene paper coating, with one layer of film performing the function of the paper. Eventually, the layers of polyethylene may be extruded over both sides of the scrim. Compared with conventional film, it has improved strength, rip and tear resistance, and dimensional stability.

• • • •

Special fluorocarbon film (*Sanstress,* Sanford Plastics Corp.), manufactured from virgin resin *(Kel-F),* withstands sterilization by all conventional methods without distortion. It is used for packaging sutures, and in the electrical and allied fields as a nonconducting wrapper for high-temperature wires and for thermal connections.

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Extruded polyethylene sheet (*Micarta Div.,* Westinghouse Electric Corp.), with room temperature tensile strength of 1700 p.s.i. and a modulus of elasticity up to 19,000 p.s.i., is intended for neutron shielding on nuclear reactors where weight and space limitations are a primary consideration. It can also be used in applications requiring chemical inertness, thick cross-section stiffness, and unlimited length.

• • • •

Nylon 6/6 film (Foster Grant Co., Inc.), now in developmental production, resists oil and organic solvents even at elevated temperatures. It can be heat-sealed when coated with oil or organic solvents. Among its suggested uses are rainwear and packaging, particularly where retention of flavor and aroma are important.

• • • •

Oriented and nonoriented nylon strip (*Reevestrip,* Reeves Brothers, Inc.) is available in thicknesses up to ⅛ in. and in widths up to 3 inches. The oriented material is used primarily as a component in the manufacture of power transmission and conveyor belts, while the non-oriented nylon strip finds use in gaskets, washers, bearing seals, etc.

• • • •

Specially formulated adhesion promoters or primers (*National Adhesives Div.,* National Starch Products, Inc.) facilitate strong and durable bonds between polyethylene and paper, foil, polyester film *(Mylar),* saran, and other materials common in the packaging industry. When applied to the substrate, the primers permit polyethylene extrusion at lower temperatures than were formerly possible. They give more slip, lower odor, better aging, and heat-seal bonding.

• • • •

Laminates (Cincinnati Industries, Inc.) of kraft paper and thin-gage plastics films can be easily thermoformed on conventional equipment. The paper used in the laminations (*X-Crepe,* Cincinnati Industries, Inc.) has a high degree of all-directional stretch, so that the thermoplastic film and paper combination can stretch as much as 60% during the forming process without breaking.

• • • •

Nylon 6 sheets *(Campco,* Chicago Molded Products) are being used (by Canning Machinery Div., Food Machinery and Chemical Corp.) to replace aluminum-extrusion doors on utensil washers. The nylon sheet was chosen because it could withstand the frequent rapid flexing required; in addition, it resists corrosion and is non-toxic.

film is designed for applications requiring high-gloss clarity, chemical inertness, and resistance to moisture vapor and common gases. It is extremely tough, having excellent tensile and tear strength, and high elongation.

Processing: Heat-sealing—important in the manufacture of furniture covers, bags, etc.—is the most common fabricating process used on cast vinyls. Cast film is also readily vacuum formed.

Applications: Laminated constructions (e.g., military barriers and cheese wrap); an overlay film on unit food packages; furniture cover material; and "skin packaging" for irregularly shaped items such as hardware parts.

Available colors: Practically all cast vinyl film, rigid and nonrigid, is clear, although work is presently being done on perfecting the use of colorants in the casting process.

Extruded vinyl film and sheeting: Extrusion of vinyl chloride and vinyl chloride-acetate resins into film and sheeting is a comparatively new field; in fact, much of it is still in the experimental stages. The resin compounds used to extrude vinyl film and sheeting have basically the same composition as those used for calendering.

Plasticized vinyl film made from this process is noted for its outstanding resistance to aging and sunlight. It also has good moisture-vapor transmission, tensile strength, tear strength, heat-sealability, clarity, and printability, and can be readily laminated to other materials.

The major market for extruded vinyl film is, of course, packaging. The material has been particularly successful in the commercial packaging of such products as paper goods, textiles, and hardware. It is not used for food packaging.

When extrusion of rigid vinyl sheeting becomes commercially practical, it should find use in packaging, laminates, lighting components, etc.

Polyvinyl alcohol film

Methods of manufacture: Band casting. The plastic base material with its modifiers is dissolved in

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Section on Polyvinyl alcohol prepared by Mono-Sol Corp., Gary, Ind.

water. This solution, with other chemicals added, is controlled for viscosity and temperature and then deposited as a wet film on a large moving belt and dried.

Types: There are two types of PVA film; namely, standard and cold water soluble. The standard type is made from the higher-molecular-weight type resins and is generally plasticized with glycerine. The cold water soluble (CWS) type film is made from internally plasticized resins or low-molecular-weight resins.

General properties: PVA film is impervious to oils, fats, and waxes and has a zero transmission rate for oxygen, hydrogen, helium, and nitrogen. The water permeability is necessarily rapid, because of the film's being made in water. PVA film has tensile strength which averages about 10,000 p.s.i. before stretching but has shown tensile strengths of more than 50,000 p.s.i. after stretching to 5 times the original length. The elongation of unstretched PVA film may vary from less than 10% to more than 600%, depending upon the plasticizer content and humidity. PVA films have excellent sunlight stability and have stood up in a Fadeometer for over 1,000 hours. The refractive index ranges from 1.49 to 1.53. The aging qualities are excellent with no yellowing. Color is slightly yellow to colorless.

Processing: PVA film readily heat-seals and may be laminated to other films, papers, etc.

Applications: The standard film is used as a relief agent in the molding of polyester resins and vacuum bag molding. The cold water soluble film is used as a water soluble packaging film and barrier coating.

Finishes: Can be made with a satin finish on one side of the PVA film and a glossy finish on the other side.

Polyvinylidene chloride copolymer film

Methods of manufacture: Polyvinylidene chloride copolymer resins are mixed with the necessary plasticizers and stabilizers, extruded, supercooled, and oriented into a thin film.

General properties: The film has excellent chemical resistance, will not support combustion, absorbs practically no water, and has very low water and gas permeability.

Processing: The film is heat-shrinkable and may be heat-sealed in the lighter gages. The best seals are obtained by using high-frequency electronic-sealing methods. The film may be laminated with adhesives to other materials, may be printed, and may be fabricated into casings, tubing, and bags.

Applications: The film is extensively used in applications where low water and gas transmission rates are desirable, such as packaging candies, processed and frozen meats, cheeses, baked goods, nuts, and cookie dough. It is often used as a cap-lining material because of its excellent chemical resistance.

Colors available: Polyvinylidene chloride copolymer film is available in a range of clear transparent, translucent, and opaque colors.

Methyl cellulose film

Methods of manufacture: Methyl cellulose film is cast by normal casting methods. Methyl cellulose (e.g. Methocel 60HG†) resin and suitable plasticizer are moved in appropriate ratios into a dissolving tank containing the selected solvents. After agitation of the mixture, the solution is filtered into the casting hopper feed tank.

The solution is fed through the casting hopper and is cast onto a stainless steel belt. The thickness of the film is controlled by regulating the rate at which the solution is fed onto the belt and the belt speed. As the film traverses the length of the belt, hot air removes the solvent which is recovered and recycled.

General properties: The excellent water-solubility of methyl cellulose film is its most important property. Although the solubility rate varies with temperature, at 77° F., 1 sq. in. of 1-mil film dissolves in water in approximately 18 seconds. Methyl cellulose film's tensile strength of 5,400 p.s.i. is adequate for packaging. With a yield point of 2,200 p.s.i., a burst strength of 17.9 p.s.i., and an elongation of approximately 58%, bags fabricated from methyl cellulose film will withstand much abuse. The film has a 1.23 specific gravity. The yield factor, 22,500 sq. in./lb./mil, and low-cost base material make methyl cellulose film reasonably priced compared with other water-soluble films. Although its outdoor uses are obviously limited, methyl cellulose film has excellent indoor aging characteristics. This film exhibits no brittleness or apparent loss of flexibility at low temperatures, even when packed in dry ice. The m.v.t. rate of the film is high. Relative humidities of 95% and over may cause the film to soften slightly, but not necessarily to block. Its high gas permeability definitely classifies methyl cellulose film as a breathing film. This property may be desirable for many applications, but it makes methyl cellulose film unsuitable for gas or vacuum packaging.

Processing: Methyl cellulose film may be readily heat-sealed with either impulse heat-sealers or hot surface sealers. The optimum heat-sealing range, 300 to 325° F., will depend on the particular formulation being used. The film may be solvent-sealed effectively with a very small controlled supply of water.

Applications: Facilitates automatic dispensing of package and contents for use in aqueous solutions; it eliminates personal contact with toxic materials, the necessity of unit measuring, and the danger of spillage; packaging powdered milk, cold drink powders, food product additives, concentrates, medicinal capsules, laundry soaps, bath powders, bleaches, tints and dyes, fertilizers, fungicides, etc.

Finishes: Methyl cellulose film is available as a clear transparent film with one side glossy, and the other matte-finished.

Modified styrene sheet

Methods of manufacture: Calendering or extrusion.

General properties: A family of materials covering a range of

(*Continued on p.* 410)

Section on Polyvinylidene chloride prepared by The Dow Chemical Co., Midland, Mich.

† Trademark of the Dow Chemical Co. This section prepared by Dow Chemical Co.

Film, sheet, and shapes

. . . for effective plant maintenance

By Richard J. Jacob*

Carrying a supply of plastics film, sheets, rods, tubes, and shapes in stock has become a fairly common practice among today's industrial plants. And a well-stocked bin can be put to many good uses—one of the most important of which can be that of plant maintenance. Listed below are some of the materials which are being used for just such a purpose. The list is indicative, but by no means exhaustive.

Acetate: Mostly used as sheets, generally clear, but in some cases tinted. Main uses are in making welder's shields, sun shades, small housings, window cartons, envelopes for shipping of small parts, templates, layouts, map covers, sheet protectors, and overlays.

Acrylic: Available in sheets, plates, rods, tubes. Shapes may be clear or translucent (mostly white, but colors also obtainable).

High light transmission and good impact resistance are utilized in machine guards, eye-, face-, and windshields, inspection windows, and, in general, where the operator or mechanism is to be protected from chips, dust, or foreign materials without impairment of the operator's ability to view and control the operation.

Cast sheets are extensively used in factory glazing, where combination of shatter- and corrosion-resistance and mechanical strength sharply reduce replacement and maintenance costs. Mostly used in translucent colors or patterned textures which also give excellent glare- and shadow-free light diffusion.

Resistance to chemicals and ease of forming and joining are responsible for material's use in fume hoods, plating fixtures, tank liners, and protective covers.

Development prototypes of new units and components are often machined from acrylic to permit engineers to view the functioning of the inside mechanism and locate faults. These prototypes are later used as models and demonstrators.

Other common applications include: partitions, housings, knobs, window glazing, dome skylights, show cases, signs, decorative plaques, drawing aids, sales and display material, sight gages, light fixtures, luminous ceilings, and light diffusers (using the translucent, generally white, materials).

Modified acrylic is finding use in partitions, housings, pumps, and parts exposed to water.

Butyrate is mainly used in letters and backgrounds for signs.

Epoxies and polyesters are generally used with fibrous glass and other types of reinforcements to produce covers, housings, construction panels, table tops, factory glazing, radomes, electrical laminates, tank linings, special tools and jigs, and for patching, especially of metals. Epoxies and polyesters are also available clear, and are being used, without reinforcements, for embedments and for casting of prototypes.

Fluorocarbon resin is available in plate, rod, tube, or tape. It provides insulation in motors and generators, in armature and field conductors, is used for slot lining, coil wrapping and taping, for separating coils, for lead insulation, and for insulator bushings. Its extremely low coefficient of friction makes it excellent for bearings and bearing liners, slides, chutes, mixer paddles, molds, and for general handling of sticky materials. Applications such as gaskets, seals, valve seats and diaphragms occur especially where corrosive chemicals or high temperatures are involved. Packings machined from rod flow under pressure in the packing gland provide an excellent seal that doesn't get dry or score valve stems.

Nylon is machined out of solid shapes or cut from continuous tapes to make bearing linings, bushings, washers, seals, spacers, packings, liners, gaskets, wear strips, roll coverings, conveyor guide rails, conveyor channels and belts, cams, gears, rollers, valves, nonmarring elements for transfer mechanisms, hydraulic lines, and tubing for other pressurized fluid lines.

Phenolic laminates are cut or machined from sheet and block to make gears, thrust washers, wear surfaces, instrument and control boards, terminal and mounting blocks, cabinets, and to build up special tools.

Polyester film goes to make temperature curtains, shims and spacers, washers, gaskets, templates, sheet protectors, insulating tapes.

Polyethylene film, sheet, or tubing makes inexpensive protective covers, drop cloths, tarpaulins, chemical pipe and couplings, tank liners, separator plates, moisture and vapor barriers, packing sheets and bags, washers, bushings, gaskets, tank liners, drip trays, leaf spring liners, electric tape, weatherproof cable sheaths, insulators, and other electrical parts.

Polystyrene is mainly used for covers and insulators; *medium-impact styrene* for light panels; and *high-impact styrene* for refrigeration and cold service parts.

Vinyl sheets and films are easily cut to make industrial aprons, tags, protective covers, temporary shelters, industrial curtains, templates, charts, layouts, laminating protection, drawing aids. Heavier sheets are used for machine guards, gaskets, dials, filters, washers. Vinyl tape is used in wrapping and to make weather stripping. Some vinyl is used for luminous ceilings and light fixtures; while vinyl tubing is available in a number of grades for insulating sleeves, wire protection, vacuum tubing, welding hose, small parts feeding, and for coolant and other low-pressure fluid flow lines.

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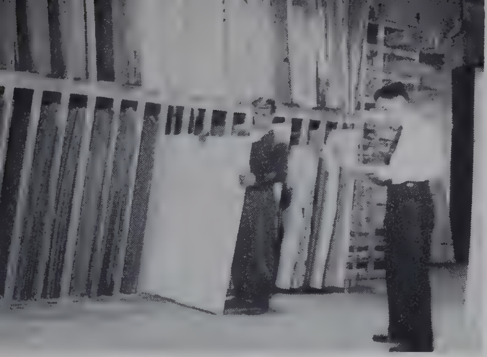
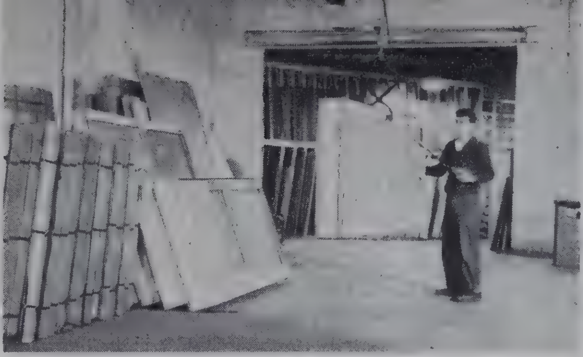
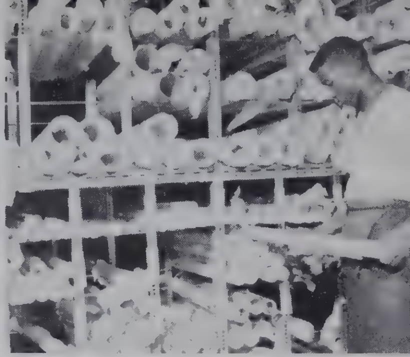
*Exec. Vice-Pres., Cadillac Plastic & Chemical Co., 15111 Second Blvd., Detroit 3, Mich.



LARGER PLASTICS SHEETS are best stored in bins close to the floor. Note that bins are not perpendicular; slanted bin openings make for easier handling of the sheets and ready identification of size and color. Protective paper wrap should be left on the sheet to prevent damage in handling



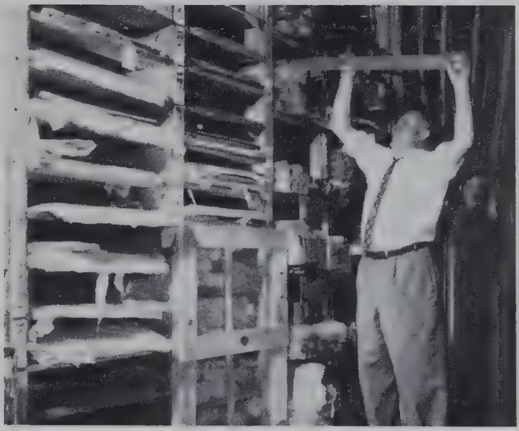
HANDLING OF CASE LOTS, especially those of considerable size and weight, is best accomplished with a grab-hook slung from an overhead crane. Hoist used should have 40% more capacity than heaviest cases likely to be handled. Cases should be stored with sufficient lean to prevent accidents or damage to other materials. Outsize sheets also should be stored in this area but kept to the fore to prevent warp or damage from weight of heavier cases against them



TUBULAR STOCKS tend to reverse normal storage procedures in that larger diameters are stored on the upper shelves. The logic is that these sizes will move out more slowly than the smaller tubes which are more in demand. Note that each tube retains its original protective paper wrapping and each bin is plainly tagged

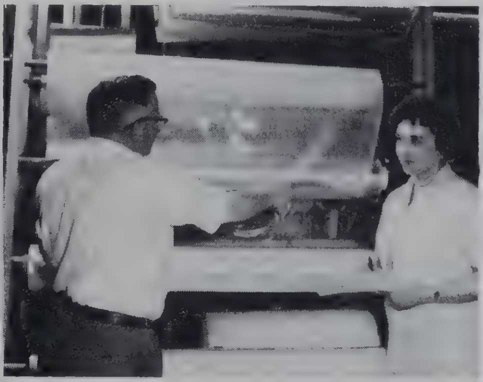
Good Housekeeping Hints

The storage and care of plastics film, sheet, and shapes while in plant stock rooms need not be a difficult or complicated job, provided it is approached with certain simple rules of good-housekeeping in mind. The photographs reproduced on this page were all taken on the premises of Commercial Plastics and Supply Co., New York, N.Y. They illustrate some of the types of racks, shelves, and handling equipment which that company has found to be particularly appropriate in solving many of their problems in the storage of a variety of plastics materials in a wide range of sizes and shapes. The descriptions accompanying the photographs, prepared by Arthur Herman, Pres. of Commercial, give the reasons why the different systems were evolved and serve as a guide to the adaptation of similar procedures for safe and efficient storage of large or small stocks.



VIEW OF STORAGE area for plastics. Smaller sheets of butyrate are stored on the horizontal, as at left, preferably with protective separating papers. The heavier the sheet or rod, the lower it should be stored

UNUSUAL sizes and thicknesses of plastics should be stored in separate area away from standards. Note the pull drawers just below the clerk's right hand, identified plainly as to contents (in this case, shorter cutoffs that might be lost if stored in open bins)



ROLLS of polyethylene film should be stored "off the floor" on some such pipe-rack arrangement as that shown above. Again, the "most called for" sizes are hung on the lower racks. Offsetting the rolls, as shown, helps in paying out lengths without interference from other rolls of film in the rack

MORE EXPENSIVE plastics (such as fluorocarbons) rods and tubes, as shown here, should be stored under lock and key for complete protection. Each size is plainly marked to facilitate selection. The clockwise progression from the smallest (upper right) to the largest (upper left) aids identification

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Film and sheet

(continued from p. 407)

fair-to-good impacts, with hardness and tensile generally decreasing with increasing impact. They are characterized by good processing and excellent forming properties.

Processing: Can be formed by any of the conventional vacuum forming techniques, and can be machined on standard machinery; parts can be easily joined by cementing.

Applications: Refrigerator and freezer liners, machine housings, cases and boxes, toys, decorative panels, display units, etc.

Colors available and methods of finishing: Available in a broad color range, mostly opaque but some translucency in the lower impact range. Can be embossed, printed, and gold-stamped.

ABS polymer sheet

Methods of manufacture: Calendering or extrusion.

General properties: A family of materials covering a range of impacts from fair to excellent. In general, hardness and tensile decrease with increasing impact. High heat distortion, good chemical resistance, good flexural strength, and improved weather resistance.

Processing: Easily formed by standard vacuum forming techniques; particularly suited for deep-drawn parts; can be machined, punched, or sewn. Parts can be easily joined by cementing, if desired.

Applications: Automotive parts, tote boxes, machine housings, luggage, cases, household appliance parts, decorative panels, display items, toys, chemical resistant ducting, etc.

Colors available: Wide range of opaque colors. Can be embossed, printed, and gold-stamped.

Oriented styrenes

Methods of manufacture: Extrusion of sheet which is stretched in two directions under accurately controlled temperature to achieve molecular orientation.

General properties: Oriented polystyrene has a tensile strength of 7000 to 12,000 p.s.i., a flexural strength of over 10,000 p.s.i., and a compressive strength of over 25,000 p.s.i. Its percent of elongation is 3 to 10. Water absorption (% 24 hr.) is 0.04 to 0.06 mils.

Oriented styrene acrylonitrile copolymer has a tensile strength of 10,000 to 15,000 p.s.i., and a flexural strength of over 15,000 p.s.i. Its percent of elongation is 40 to 70. Water absorption (% 24 hr.) is 0.5 (maximum).

Processing: Both oriented sheet materials can be printed, laminated, slit, sheeted, die-cut, folded, and pressure or vacuum formed. Adhesives and methods of handling are improving. They are heat-sealable with special equipment and techniques.

Applications: Oriented styrene is used for special photographic film base, lamination to impact styrene, printed and formed signs and displays, printed place mats, light shielding, metalizing, package covers and components, and complete heat-sealed packages for food items.

A packaging film has recently been made available that offers transparency, low cost, and excellent dimensional stability and aging qualities. It is recommended for package overwraps, bags and pouches, and envelope and carton windows.

Oriented styrene acrylonitrile copolymer is used as a glass substitute for storm windows and temporary enclosures, lamination to ABS materials, packaging, signs, and displays.

Colors available: Clear transparent and translucent colors.

Polyethylene film

Methods of manufacture: See section on "Extrusion: Polyethylene," p. 684.

General properties: Good tensile, tear, and impact strength with unusually good performance at low temperatures; low moisture vapor permeability, high gas permeability; low density, therefore high area yield factor; odorless, tasteless, colorless.

Sections on Modified styrene and ABS polymer prepared by Naugatuck Chemical Div., U.S. Rubber Co., Naugatuck, Conn.

Section on Oriented styrenes prepared by Plax Corp., Hartford, Conn.

Section on Polyethylene film prepared by Visking Co., Div. Union Carbide Corp., Terre Haute, Ind.

Processing: Fabrication by heat-sealing on commercially available equipment. Printing on specially treated types with commercial inks on commercial presses. Pressure-sensitive adhesives can be used.

Applications: Food packaging; soft goods packaging; hardware packaging; moisture barrier in building trades; concrete curing blanket; Stratosphere balloons; tarpaulins and agricultural uses, e.g., silo covers, crop mulch, etc.; drum liners; and automotive seat covers.

Colors available and methods of finishing: Natural, black, white, full line of standard colors and pastels; also, embossed.

Cellulose acetate film

Methods of manufacture: A) Casting: In this operation, cellulose acetate flake, plasticizers and other modifiers are dissolved in a suitable solvent; this solution is then deposited as a wet film on a large moving wheel or belt and dried under carefully controlled conditions. B) Extrusion.

General properties: Crystal clarity; wrinkle resistance; greaseproofness; water resistance; dimensional stability; high gas permeability; good electrical insulation properties; resistance to fogging; and medium water vapor transmission.

Processing: Readily formed by heat; easily fabricated; readily solvent-sealed; metalizable; heat-sealable; and easily printed by rotogravure, flexographic, and silk screen printing.

Applications: Prepackaging produce; packaged bakery products; overwraps; window cartons; window envelopes; laminates; electrical insulation; rigid containers; printed signs and displays; book covers; sound recording tape; glazing materials; lamp shades; pressure-sensitive tape; gold-stamping foil; protective folders and covers; metalized ribbons; sun shades and curtains; and vacuum formed parts.

Colors available and methods of finishing: Extruded material is available in crystal and in transparent, translucent, and opaque colors. Cast material is available

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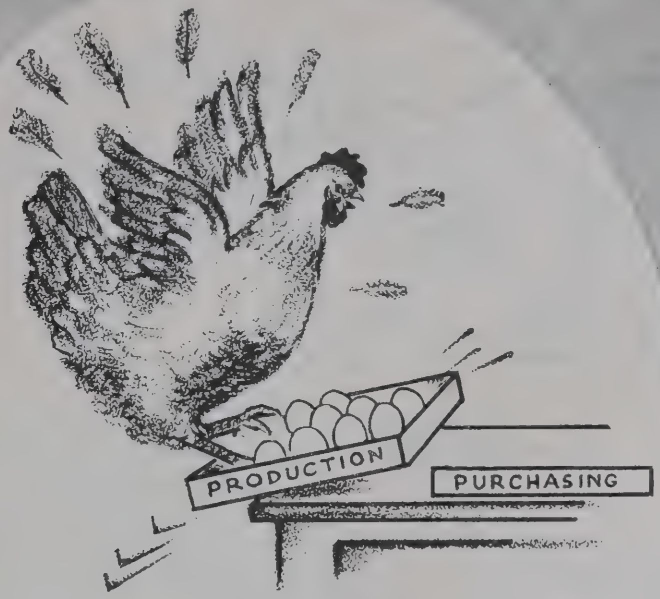
Sections on Cellulose acetate prepared by Celanese Corp. of America, Newark, N. J.



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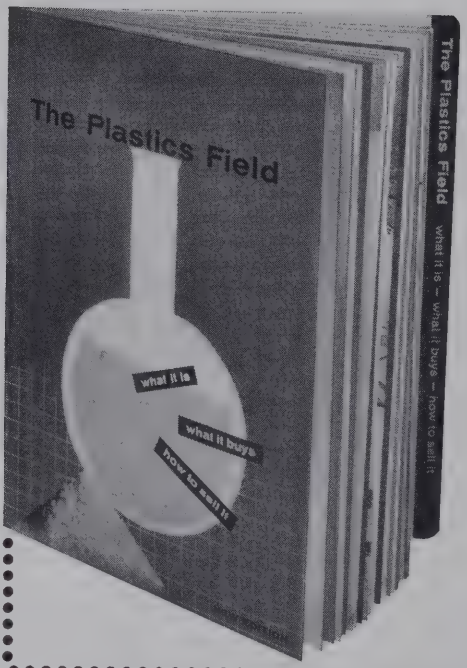
The Plastics Field
what it is
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The Plastics Field what it is — what it buys — how to sell it

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in crystal and in surface-colored transparents. Cellulose acetate film can be printed, embossed, and gold-leaf stamped.

Cellulose acetate sheet

Methods of manufacture: Extruded. Hot pressing of sheets is used to improve optical quality or to achieve special effects. Laminates, combining two or more colors, are available.

General properties: Same as for acetate film, above.

Processing: Readily formed by heat; readily solvent-sealed; easily metalized; can be hot-formed, blown, drawn, and solvent-stretched; heat-sealable; easily printed; and can be cut, blanked, stamped, stitched, drilled, punched, embossed, laminated, and cemented.

Applications: Machine guards; laminates; electrical insulation; rigid containers; printed signs and displays; welders' shields and safety lenses; glazing materials; truck curtains; protective folders and covers; metalized sequins; sun shades and curtains; vacuum formed parts; book covers; eyeglass frames; and handbags.

Colors available and methods of finishing: Available in crystal, in pearls, and in transparent, translucent, and opaque colors. Can be finished by embossing, printing, and gold-leaf stamping.

Cellulose triacetate film

Methods of manufacture: Cast from clear solutions on to slowly moving drum-like wheels with highly polished surfaces.

General properties: A rigid-type film with high tensile strength, high heat resistance, and low shrinkage. It is characterized by its excellent clarity, gage uniformity, dimensional stability, and high dielectric strength.

Processing: Easily sealed to paper, board, or metallic foils; readily accepts inks for all methods of printing. Has good surface "slip" for high-speed fabricating equipment.

Applications: Window boxes and envelopes; magnetic recording tape; reverse printed window streamers; foil-laminated packaging; transformer windings;

Sections on Cellulose triacetate and Cellulose butyrate prepared by Eastman Kodak Co., Rochester, N. Y.

book jackets; and various types of novelty and decorative ribbons for packaging.

Colors and finish: Crystal clear gloss finish. (Dyes commercially available for tinting.)

Cellulose triacetate sheet

Methods of manufacture: Cast. Same as cellulose triacetate film.

General properties: A clear transparent sheet, with higher physical and chemical stability. Though rigid, it has excellent folding endurance. Unaffected by grease or water. High spectral transmission with minimum discoloration on exposure to sunlight. Brilliant surface finish. Uniform gage.

Processing: Provides deep draws by heated punch and dies, but softening temperature is too high for vacuum forming. Can be high-frequency sealed. Special types available for solvent-sealing. Readily printed by all methods, including silk screening. Ideal for container manufacture with automatic box-making equipment. Easily slit, guillotined, or die-cut.

Applications: Transparent containers; folders and shop ticket protectors; wallet inserts; safety goggles; slot cell insulation; index tabs; filing equipment; greeting cards; counter displays; lampshades; microfilm holders; visual aid transparencies; map and chart overlays; menu covers.

Butyrate film

Methods of manufacture: Cast. Same as cellulose triacetate film.

General properties: Softer than most cellulose ester films; low moisture absorption; tough, with stretch up to 45% elongation; resistant to water, detergents, and dry cleaning solvents.

Processing: Excellent for laminating to metallic foils; can be slit to very narrow widths; runs easily in looms and high-speed wire winding equipment.

Applications: Metallic yarns and ribbons; wire insulation.

Colors available: Clear transparent.

Butyrate sheet

Method of manufacture: Extrusion.

General properties: Low mois-

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ture absorption; forms easily without blushing; superior resistance to outdoor weathering; gage and surface less uniform than cast sheets; high impact strength and shock resistance.

Processing: Excellent for all types of vacuum forming. Seals either with solvents or electronically. Readily printed either direct or in reverse. Suitable for vacuum metalizing, embossing, or hot-stamping.

Applications: Skin and blister packaging; advertising displays; outdoor signs; explosion-vent windows; industrial face shields; safety goggles; and instrument dials.

Colors available and methods of finishing: Clear transparent and translucent white; as extruded, polished, and matte surfaces. Other colors available on special order.

Acrylics

There are two types of acrylic sheet available: extruded and cast. Extruded sheet is produced from acrylic solid polymers by a melt process through suitable dies. Cast sheet is produced from acrylic liquid monomers by a polymerization process in suitable molds.

The significant differences between cast and extruded acrylic sheet are in strength and resistance to heat (cast is higher). Differences in optical properties are slight. Chemical, dielectric, and weathering properties appear to be the same.

Cast sheet is usually recommended where the application requires the maximum in surface finish, clarity, toughness, and heat resistance. Extruded has been manufactured in recent years with much higher quality finish than was formerly the case, and is now acceptable for a wider range of quality-finish applications.

In general, fabricating methods and procedures are the same for both cast and extruded materials, except for the following: Forming temperatures for cast sheet run about 35 to 60° higher than for extruded. Recommended oven temperatures for extruded are

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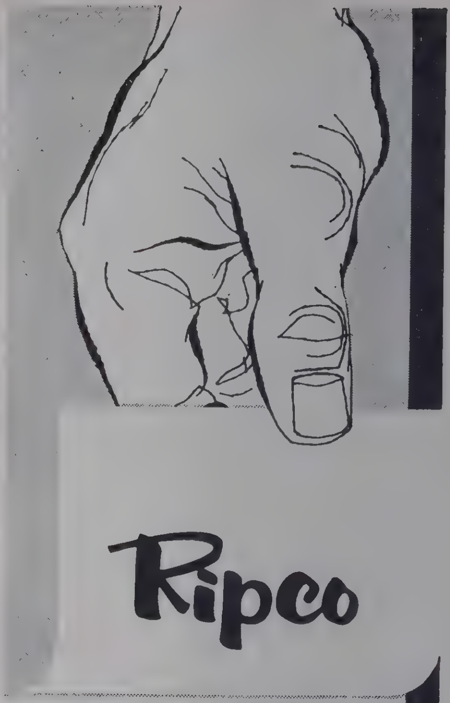
Section on Acrylics prepared by Cadillac Plastic and Chemical Co., Detroit, Mich.



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APPLICATIONS

Ideal for pressure sensitive backing . . . tapes and labels; decals; board and bag lining; corrugating. Or casting paper for polyurethane foams, polyesters, and plastics; packaging or processing synthetic rubber and asphaltic products; and for in-plant meat processing and food packaging.

260 to 305° F. and for cast, 290 to 340° F. It is not safe to heat extruded above 325° F., or cast above 360° F.

At forming temperatures, extruded sheets are softer than cast and require a greater number of clamps for support. They also have a greater tendency to stick together if touched or folded.

Cementing of extruded materials usually requires a less active or milder cement than for cast acrylics. The soak method of cementing may not be used with extruded materials. Dip and capillary methods are recommended as being more suitable.

Airplane canopies and windows, outdoor signs, and displays are representative uses of acrylics. Acrylics offer optimum clarity and good light transmission. They are strong, rigid, and resistant to sharp blows.

Polyester film

Method of manufacture: Made by flat casting of the polyester polymer and subsequent treatment to produce the polyester film.

General properties: It is a clear, tough film (about ⅓ the strength of machine steel), with good elongation and impact resistance. It has very low moisture absorption, is dimensionally stable under extremes of temperature and humidity, with good retention of its physical properties. It has a low moisture vapor transmission rate, its permeability to gases is very low, and it does not embrittle at temperatures as low as —60° C. The film has a high melting point (250 to 255° C.) and is slow burning. It can be run on packaging machines and heat-sealed with the use of benzyl alcohol. It also has excellent resistance to acids, greases, oils, and organic solvents. Strong alkalies will affect the film, especially when hot. The polyester film has well-balanced electrical properties as measured by its good dielectric strength, high insulation resistance, and low dissipation factor.

Processing: The film is readily printed, embossed, or delustered. It is used for metalizing and can

---

Sections on Polyester film and Cellophane prepared by E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.

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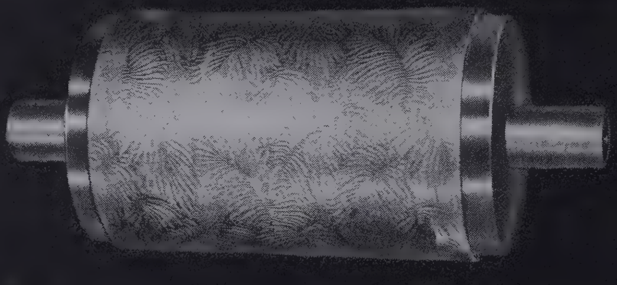

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CHROMIUM CORPORATION OF AMERICA

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be laminated to a wide variety of materials. Coatings add to its versatility in making bags and in various packaging applications. It can be run on packaging machines, used as an overwrap, etc.

Applications: This film is successfully used in conveyor belts, transformers, capacitors, motor insulation, insulating tape, wire and cable, metallic yarn, as a gas barrier, cartography, magnetic recording tape, and general packaging. In addition, there are many unique industrial uses. A weatherable type is available for outdoor applications.

Colors available and methods of finishing: The clear film in roll or sheet form is available from the manufacturer, but processors are now making it available in many colors and special put-ups.

TFCE film and sheeting

Methods of manufacture: Sheeting is made by compression molding between release plates; film is made by extrusion in the form of tubing and in the form of slit-die material.

General properties: The film is tough, nonwetting, nonporous, clear, colorless, and transparent. It may be sterilized by heat or radiation. The moisture absorption is zero and moisture vapor transmission is extremely low. Permeability to most gases is also very low. The useful temperature range of the film is −320 to +350° F. The film is noncarbonizing and nonflammable. It is extremely inert to chemical attack and will not contaminate or be affected by acids, alkalies, greases, oils, and most organic solvents. The dielectric strength over a wide frequency, temperature, and humidity range is high, and the loss factor is low. Films made from the copolymers suffer no appreciable loss in physical properties when subjected to irradiation dosages as high as 20 megareps.

Processing: The film is easily sealed by thermal impulse or high-frequency methods without adhesion aids. It can be vacuum or drape formed. It can be printed upon with special inks or marked by hot-stamping. It can be sur-

---

Section on TFCE prepared by Minnesota Mining and Mfg. Co., St. Paul 6, Minn.

Glamor—where "the rub comes"—for Eastern's new Jet-Powered Electras

Interiors of originality and beauty . . . with a freshness that stays fresh, trip after trip!

That's the keynote of Eastern Air Lines' new Jet-Powered Golden Falcon Electras. That's the reason, too, for metallized plastic panels*—made from Kodapak Sheet at wear points: top and base rails, valances, and other vulnerable areas.

Why Kodapak Sheet? Tough and transparent Kodapak provides a stable base to which a thin film of metallized material can be laminated economically. Finally, to guard the sparkle, the metallic film itself is protected by a second ply of clear, abrasion-resistant Kodapak Sheet.

What does this mean? Much, if you are an interior decorator or a manufacturer. For Kodapak Sheet offers exciting new possibilities in décor and surface protection. Call our representative, or write.

*Produced by High Vacuum Metals, Inc., New York, N. Y.

Kodapak Sheet

"Kodapak" is a trademark for Eastman's plastic sheet.

Cellulose Products Division, EASTMAN KODAK COMPANY, Rochester 4, N. Y.

Sales Offices: *New York, Chicago, Atlanta.* Sales Representatives: *Cleveland, Philadelphia, Providence.*
Distributors: *San Francisco, Los Angeles, Portland, Seattle (Wilson & Geo. Meyer & Co.), Toronto, Montreal (Paper Sales, Ltd.)*

face-treated and bonded to substrates with conventional adhesives.

Colors available: Film is generally used in the natural clear, transparent form; however, it can be pigmented to almost any color.

Applications: Film and sheet are used in tank and pipe lining. The film is used in packaging operations where the service is unusually critical, corrosive, or moisture-sensitive. Packages are sterilized by steam or irradiation. Printed circuitry and connective cable assemblies fabricated from film are used by the electronics industry. Film is also used in gasketing and diaphragm applications.

Cellophane

General properties: A relatively tough, transparent sheet. Uncoated cellophane is hygroscopic, tougher when moist, and more friable when dry. Softeners, such as glycerol, are added to improve its durability. It is difficult to start a tear in cellophane, but once started it tears easily.

It is slow burning, but it can be treated to make it nonflammable.

It is not water-vapor-proof as manufactured, but can be made so with coatings. It is grease and oil impermeable. Types that are resistant to water are made.

The film will change dimensionally with changes in relative humidity.

Processing: Cellophane can be printed by all standard processes, formed into bags, or overwrapped on almost any package. All types can be sealed by adhesives, and practically all coated types can be heat-sealed to themselves. Standard packaging machines can be used to process the film in the roll form, and semi-automatic machines can be used with sheets.

It can be laminated to other films, foils, and papers to obtain desirable characteristics of both materials.

Applications: The major use for cellophane is in the packaging field as bags, direct wraps, and as overwraps of trays and cartons. It is widely used as a base for pressure-sensitive tape and is used also as a parting sheet in low-pressure laminations and in other special industrial applications.

Cellophane is available in a wide variety of colors.

References

Consult the Subject Index for additional information on plastic films and sheeting. See also the Plastics Films Chart for information on properties and trade designations. For sources of plastics film and sheeting, consult Directory Index, p. 1078.

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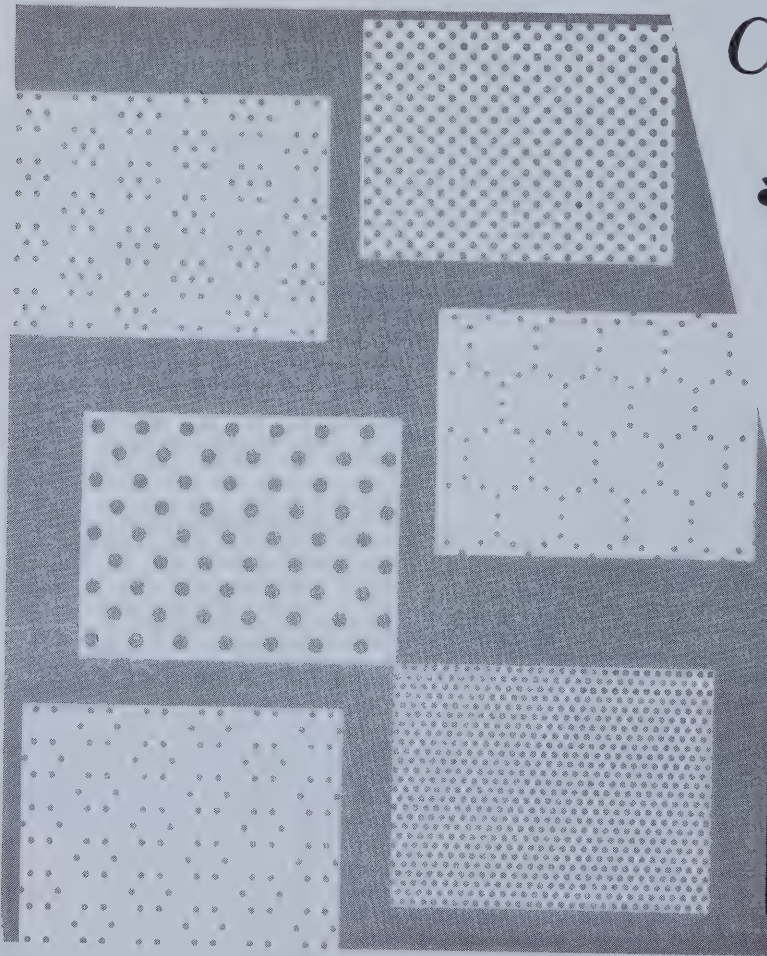

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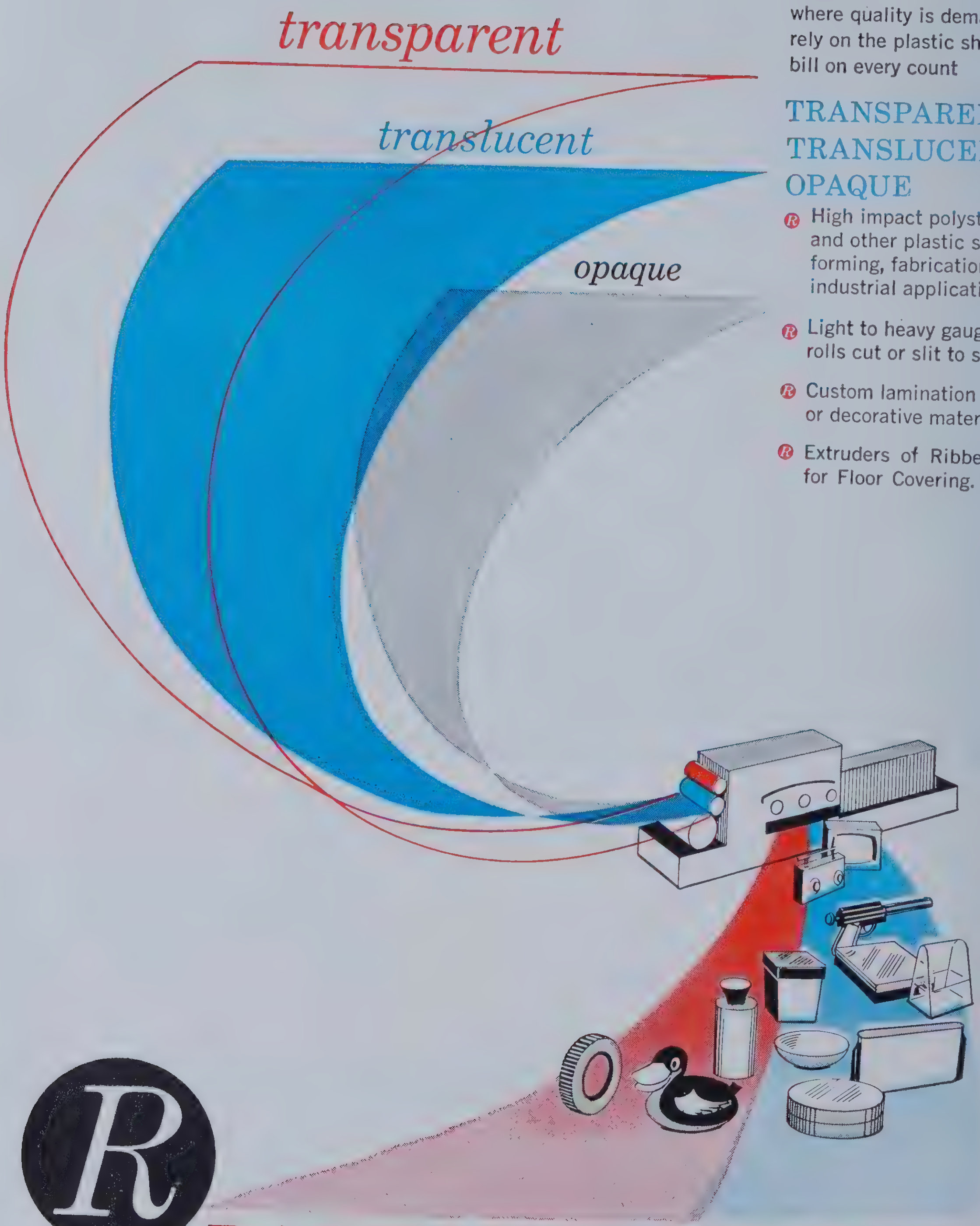

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These materials:

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S-300 Styrene—Similar to S-540 but with greater rigidity. Good impact strength.

S-1029 Tripolymer Styrene—High impact, tensile and flexural strength at extreme temperatures. Excellent chemical resistance and dimensional stability, low moisture absorption. Forms easily, machines readily. In smooth or Haircell grain finish, gauges .020″ to .125″, many colors. For luggage, housings, chairs, ducts, exhaust hoods, clock cases.

CELLULOSICS A-130 Cellulose Acetate—Strong and tough. Vacuum or pressure form. Machines well. In gauges .003″ to .060″ transparent, translucent, opaque, clear and colors. For blister packs, wraps, displays, toys, novelties, indoor signs.

B-120 Cellulose Butyrate—Exceptional strength in thin sections. Weathers well. Vacuum or pressure form, cut, blank, stamp, stitch, drill, punch. Gauges .003″ to .125″ transparent, translucent and opaque, clear and colors, stock or custom sizes. Easy to decorate by either lacquer or silk-screening. For blister packs, outdoor signs, displays, toys, novelties.

POLYETHYLENE PE-200 Linear Polyethylene—Rigid, tough, heat and chemical resistant with dielectric properties. Forms, machines, welds. Gauges .020″ to .125″ custom sheets and rolls. For housewares, containers, vessels, electrical products, toys, housing, packaging.

PE-100 Low Density Polyethylene — Low melt viscosity, excellent chemical and heat resistance. Stable under humidity changes. Vacuum form. Processes rapidly. In gauges .015 to .125″ gloss finish custom sheets and rolls. For housewares, packaging, toys, containers, form liners, electronic applications.

POLYPROPYLENE PP-300 Polypropylene—Impervious to stress cracking. Excellent dielectric properties, chemical resistance, rigidity, strength. Heat resistant to 300°F. Low specific gravity. Gauges .010 to .250 custom sheets and rolls, variety of colors. For chemical ducts and vats, fittings, electrical parts, sterile items.

NYLON N-106 Nylon — Heat form, machine stamp or die-cut. High melt viscosity, wide molten range. Excellent chemical and abrasive resistance. Self lubricating. Unlimited colors, 20″ to 40″ widths, gauges .005″ to .060″. For washers, grommets, gears, bearings, industrial glazing, packaging, food handling trays.

The range of CAMPCO applications is almost without limit. We would like to work with you in making the best use of these versatile materials. Write or phone today.

NOTE: See the Directory Section for particulars on Chicago Molded's unmatched custom molding services for plastics of all kinds.

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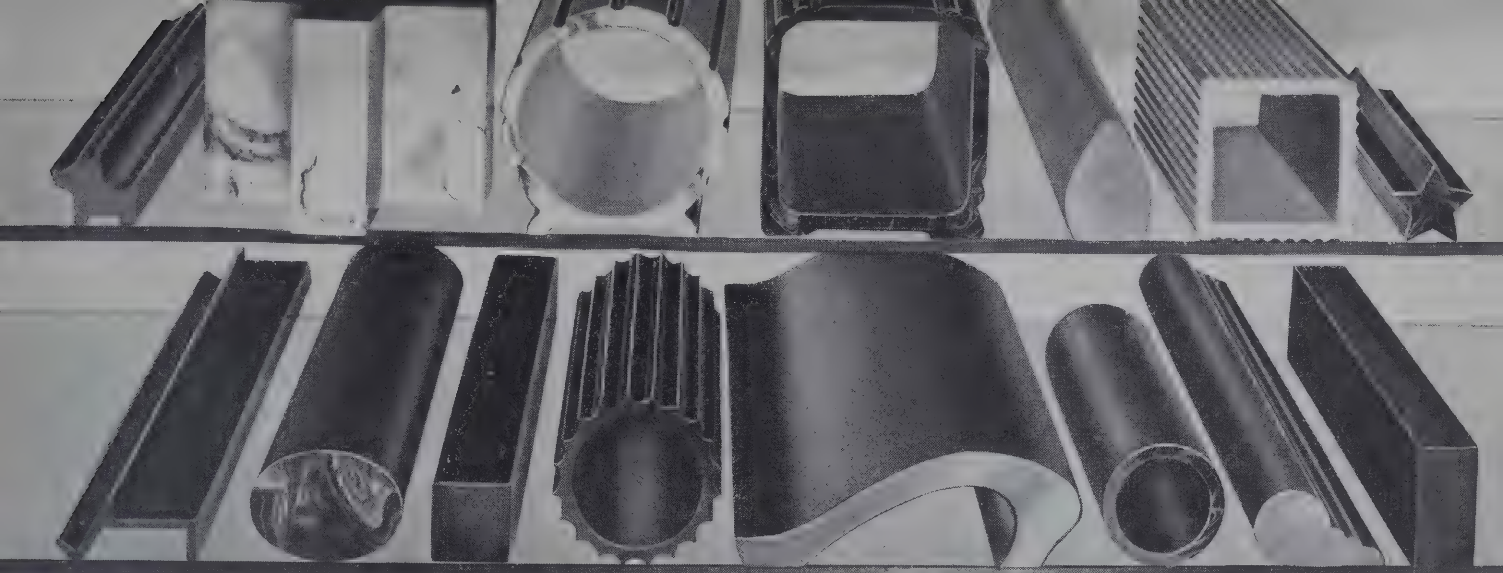

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Marblette is sold in sheets, rods, tubes and special shapes in forms and colors designated below.

Jewel-like depth and complete color range enable Marblette to duplicate the appearance of such precious stones as amber, jade, coral, etc., as well as tortoise shell and ivory.

Marblette can be had in transparent, translucent and opaque forms in an infinite variety of plain colors and mottled effects.

Marblette can be supplied in water-clear form known as "Crystle" which is also made in a wide range of colors and shades.

PROPERTIES

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Specific Volume, cubic inch per lb.	20-23
Tensile Strength, lbs. per sq. inch	8000-12000
Compressive Strength, lbs. per sq. inch	15000-30000
Impact Strength, ft. lbs. per inch of notch (Izod Test)	0.40-0.50
Modulus of Elasticity, lbs. per sq. inch x 10^5	4
Thermal Conductivity)10^4 cal., per second, per square cm/1° C. per cm	3-5
Thermal Expansion 10^5 per degree C.	8-11
Specific heat, cal. per degree C. per gram.	0.3-0.4
Heat resistance, °F.	170°
Water absorption, % by weight, 48 hours	0.4-0.6
Volume resistivity, ohm-cms (50% relative humidity and 25° C.)	10^{12}-10^{13}
Breakdown Voltage, 60 cycles, volts per mil. (instantaneous)	300-450
Dielectric constant, 10^6 cycles	5-7
Power Factor, radio frequencies	1-4.5
Power Factor, 60 cycles	0.10-0.15
Refractive Index Nd	1.5-1.7
Burning Rate	Nil
Effect of Weak Acids	No effect
Effect of Strong Acids	None to slight effect
Effect of Strong Alkalies	Decomposes
Effect of Ageing	Hardens & Yellows
Effect on Metal Inserts	None
Machining Qualities	Excellent
Clarity	Waterclear, Opaque, Translucent
Color Possibilities	Unlimited

MACHINING CHARACTERISTICS

Drilling: High speed vertical drill.

Tapping: On vertical or horizontal machines.

Turning: 450 to 600 RPM regulated to surface speed of 600′/minute. No special tool materials necessary.

Stamping: Roll leaf method usually used.

Cutting: Use abrasion cut-off wheels with water; polish by hand or tumbling.

Polishing: Use double spindle buffing lathe with soft muslin discs.

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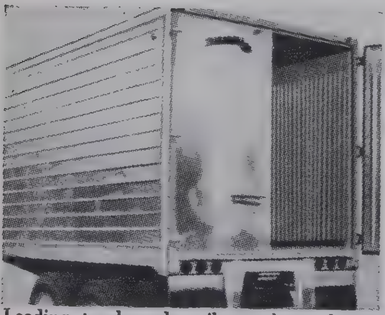

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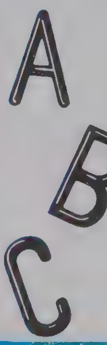

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7/8″	√			√		√	
1″	√	√	√	√	√	√	
1 1/8″	√	√		√	√	√	
1 3/16″	√			√			
1 1/4″		√		√		√	
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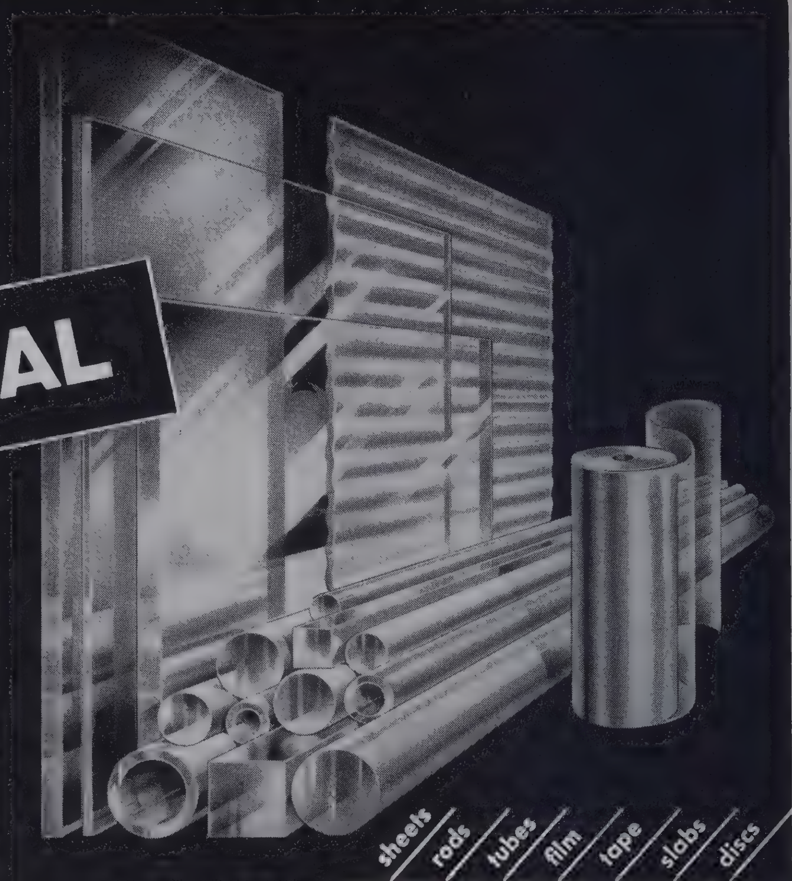

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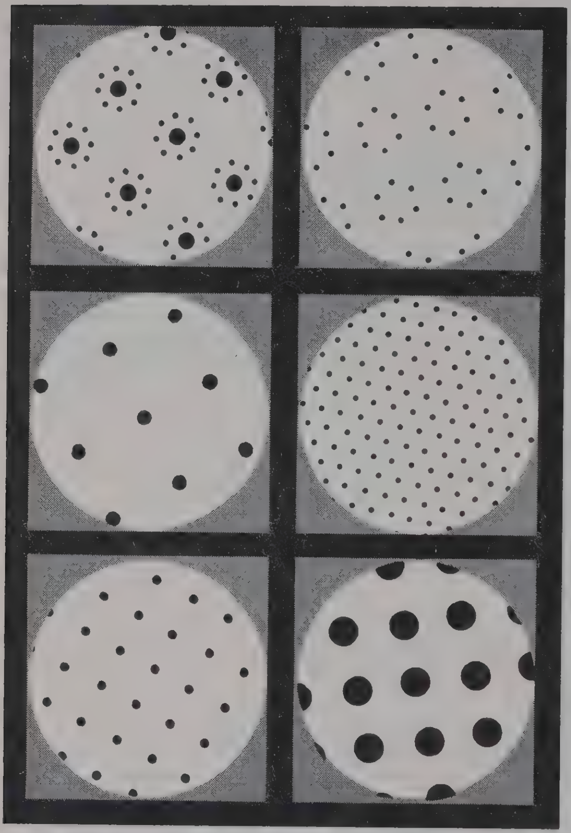

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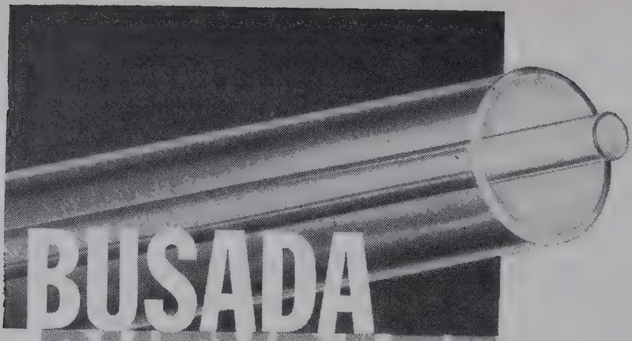

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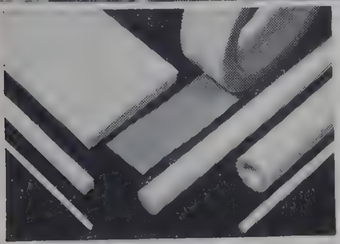

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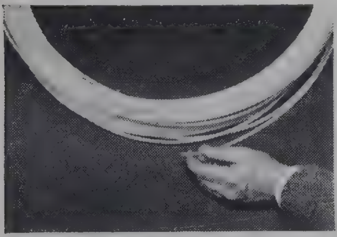

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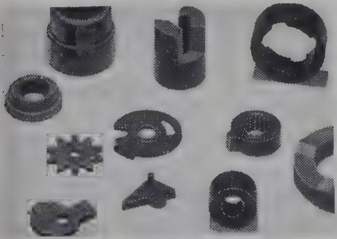

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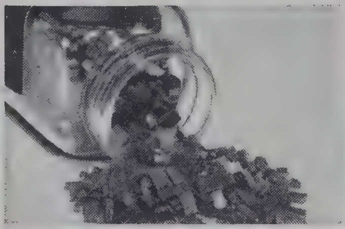

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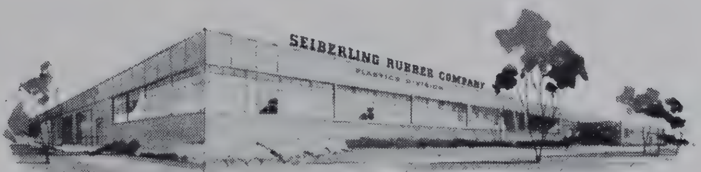
CR	Type I PVC corrosion.
HI	Type II PVC corrosion.
LC	Copolymer vinyl sheets for printing, laminating and vacuum forming.
VHI	Highest impact copolymer vinyl sheets for printing, laminating and vacuum forming.
TTT	Highest impact PVC sheets for printing, laminating and vacuum forming.
S-3	Tough thermoplastic ABS polymer for vacuum forming.
ETH	Extruded polyethylene for vacuum forming; also for fabrication of corrosion-resisting equipment.
ETH-R	Extruded rigid high density polyethylene for vacuum forming and fabrication.
PRO	Extruded polypropylene.

SEILON



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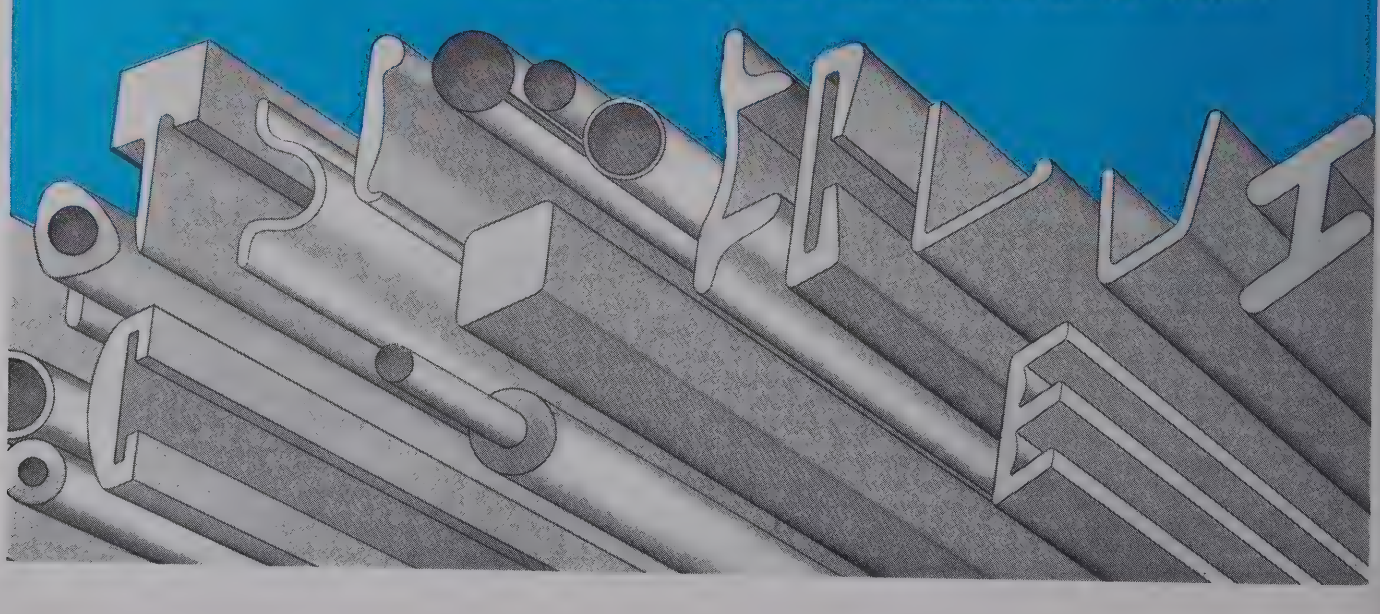

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Fillers and Reinforcements

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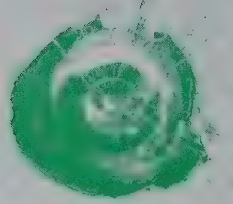

FILLERS AND REINFORCEMENTS

Fillers for molding compounds

By Raymond B. Seymour*

The utility of fillers—which vary widely in composition, physical form, and cost—is determined almost entirely by the physical, chemical, and electrical properties of the final molded product.

Resistance to impact

Since fillers reduce brittleness (and increase resistance to impact), phenolic molding compounds are often classified in accordance with the relative impact strengths of the molded products. Unfortunately, the impact values are usually based on the brittleness of notched specimens, even though the elimination of notches is a basic requirement for good plastics design.

In the absence of related end-use knowledge and experience, the published impact data are of limited value in the selection of specific types of molding compounds. At best, these values are relative. For example, a specimen molded from A.S.T.M. Type 6 phenolic molding powder, having an impact value of 4.0, is less brittle than one molded from Type 2, which has a value of 0.24, but it is erroneous to state that Type 6 has an impact resistance 16 times greater than Type 2.

Impact values are very useful in checking quality and consistency within a general class of molding compositions. But it is incorrect to assume that different molding compounds with similar impact resistance values will exhibit comparable resistance to physical damage under actual conditions of use.

Obviously, other properties must also be compared in the selection of molding compounds.

Types of fillers

As might be anticipated, many of the commercially used fillers are fibrous in nature. They may be inorganic materials such as glass, or organic materials as wood flour or cotton flock.

The organic fillers are sometimes classified as cellulose derivatives, lignin, protein, and carbon. These may be subdivided as shown in Table I, p. 437. Inorganic or mineral fillers are usually described generically.

Wood flour: Most of the wood flour used as fillers for molding compounds is obtained by attrition-type grinding of soft woods, such as Douglas fir, Norway fir, ponderosa pine, sugar pine, spruce, poplar, basswood, and cottonwood. The specific gravity of most soft wood flour when compressed is approximately 1.4. When equal parts of wood flour and resin are used, the specific gravity of the molded part will be approximately 1.35. Contamination from knots, bark, and resin spots must be kept at a minimum. Moisture should also be kept below 8% and preferably not over 5 percent.

Shell flour: When walnut shell flour is used in place of wood flour, molded parts with slightly lower resistance to impact but somewhat higher moisture resistance are obtained. Shell flour, as well as residues from furfural manufacture, may be used as an extender for resin glues, but there is no significant use of these products at present in phenolic molding compounds.

Cotton flock: Cotton flock is used for the production of medium-impact molding powders. Such products exhibit slightly less shrinkage during molding than wood flour-filled materials, but are more expensive and less readily molded. It should be noted, however, that dark-colored cotton flock (as opposed to white cotton flock) can be used in dark-shade phenolic moldings and costs less than wood flour fillers.

Cotton flock can be prepared to exact customer specifications on bulk, chemical properties, color, and fiber length.

Macerated fabric: Molding compositions containing chopped fabric have outstanding resistance to impact but are extremely bulky and are difficult to preform and mold. They are finding considerable use, however, when other products with normal impact resistance are not satisfactory.

One manufacturer has expressed the opinion that fabrics which are not cleanly cut, but which have loose fibers on the

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*President, Alcylite Plastics and Chemical Corp., Newhall, Calif.

The assistance of the following who aided in the preparation of this article is greatly appreciated: J. Baum, W. P. Bennett, and A. A. Vacca, Loven Chemical of Calif.; R. T. Brotz, Plastics Engineering Co.; R. G. Booty, Booty Resineers, Inc.; R. W. Forbes, Plastics and Coal Chemicals Div., Allied Chemical Corp.; A. W. Hammer, Jr., Durez Plastics Div., Hooker Chemical Corp.; W. H. Meadowcroft, Weyerhaeuser Timber Co.

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References were prepared by the editors.

edge of the cuttings, can, in many cases, give greater strength than cleanly cut materials. The loose fibers tend to interlock and do a better job of filling the plastic.

Sisal fibers: Chopped sisal fiber may be used alone or with wood flour. Sisal-filled phenolic molding compound is available in the form of discrete chips, in contrast to the granular consistency of wood flour-filled material.

Lignin fillers: According to the principal producer of ground fir bark, substantial quantities of this product are used by Eastern molding compound manufacturers. This product is also used extensively in the West as an extender for phenolic resin glues used in making plywood.

It has been claimed that the flow characteristics of bark flour products make exceptionally high loadings possible. The producers of fillers derived from Douglas fir bark claim economies as a result of a decrease in resin content of the resulting molding powder.

These claims have been substantiated by experiments conducted in molding compound producers' laboratories. One of the leading producers of phenolic molding compounds for deep-draw molding, however, has not been able to substantiate these laboratory results in actual production; this company found that the surface of the last third of the molded article was unsatisfactory whenever deep draws of 20 to 22 in. were attempted using phenolic molding compounds containing bark fillers.

Asbestos: The bulk of asbestos products used as fillers in phenolics molding compositions are classified as "floats." Molded asbestos-filled products have a high specific gravity and possess excellent resistance to heat and chemicals.

Amphibole asbestos makes a good filler because it has practically no water in its composition, is acid resistant (about 95% insoluble in direct contact with hydrochloric or sulfuric acid), and has very low shrinkage. (See also "Asbestos Reinforcements," p. 448.)

Synthetic fibers: Fillers can also be fabricated from such synthetic fibers as Orlon and Dacron. In some cases, this type of material is precision-cut to length from virgin fiber; in other cases, flock and chopped fabric are made from carefully selected waste material. The electrical properties and impact strength obtained can be quite good.

There has also been some experimentation with precision-cut saran and random-cut Dynel fibers. Production of flock from these fibers does not change the fibers' inherent chemical or physical characteristics, except to reduce physical size.

Wollastonite is the generic name for a natural form of calcium silicate which has been adopted as a filler for phenolic and other molding compounds. Its most outstanding properties are its brilliant whiteness, remarkable physical and chemical uniformity, and fibrous nature. Because of its structure, it may be ground in a high-shear mill to a very fluffy acicular product.

When used in phenolic molding compounds, Wollastonite improves the physical properties of the compounds. In polyester molding compounds, high concentrations of Wollastonite impart smooth surface, whiteness, and low water absorption, without exceeding a practical working viscosity.

Miscellaneous fillers: A wide variety of fillers are used in polyester and epoxy molding compounds. Clay and amorphous silica have been used to regulate flow. These compositions also may contain calcium carbonate and asbestos. Similar fillers along with carbon or other pigments are used in other molding compositions.

Manufacturing methods

Methods of manufacturing each of these fillers are as follows:

Wood flour is produced by a process that may be described as defibering, rather than cutting. Providing the size reduction is

Table I: Types of fillers for molding compounds

Organic fillers

- A) Cellulose derivatives
  - 1) Ground flours
    - a) Soft wood flours (e.g., pine)
    - b) Hard wood flours, (e.g., maple)
    - c) Shell flour (e.g., walnut shell)
    - d) Natural byproducts (e.g., cotton seed hulls)
  - 2) Cellulosic fibers
    - a) Cotton flock
    - b) Alpha cellulose
    - c) Sisal fiber
  - 3) Comminuted cellulose
    - a) Chopped paper
    - b) Diced resin board
    - c) Creped paper
    - d) Pulp preforms
    - e) Textile byproducts (e.g., macerated fabric)
- B) Lignin and lignin-extended fillers (including ground bark)
- C) Protein fillers
  - 1) Protein meal (e.g., soybean meal)
  - 2) Keratin (e.g., ground feathers)
- D) Nylon filler
- E) Carbon fillers
  - 1) Graphite
  - 2) Carbon black

Inorganic (mineral) fillers

- A) Asbestos
- B) Mica
- C) Diatomaceous earth
- D) Chalk
- E) Glass fibers
- F) Miscellaneous: barium sulfate, litharge, clay, etc.

TABLE II: Comparative properties of molding compounds with various fillers[1]

Filler	*Impact resistance*	*Cost*	*Specific gravity*	*Moisture resistance*	*Mold shrinkage*	*Mold-ability*	*Color*	*Chemical resistance*	*Resistance to heat*	*Total*
100-mesh pine	5	9	9	6	7	10	9	5	6	66
80-mesh fir	6	9	9	6	7	10	8	5	6	66
100-mesh walnut shell	4	9	9	7	6	10	7	5	6	63
Cotton flock	7	3	9	5	8	8	8	4	6	58
Alpha-cellulose	6	4	9	4	8	10	10	4	6	61
Macerated fabric	8	2	9	5	8	6	6	4	6	54
Fir bark	5	10	9	6	7	10	7	5	6	65
Soybean meal	3	10	9	3	6	7	7	3	5	53
Nylon	7	1	10	6	1	6	8	4	6	49
Carbon black	1	5	5	9	8	6	1	7	7	49
Asbestos floats	6	8	4	9	9	8	7	7	8	66
Mica	3	6	4	10	9	4	9	7	7	59
Diatomaceous earth	3	6	5	9	9	5	9	7	7	60
Chalk	3	10	4	9	9	3	10	7	8	63
Glass fiber	10	1	4	9	9	4	6	7	9	59
Sisal fiber	6	8	9	5	7	8	9	4	6	62
No filler	2	5	10	3	3	2	5	7	5	48

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[1] Empirical index values from 1 to 10 have been assigned, with 10 being most desirable. Values have been given equal weights in arriving at totals.

not too great, this attrition-type grinding preserves some of the original fiber structure. The typical fiber in 100 mesh wood flour is 0.004 in. long and has a cross-section of 0.00004 inch.

Shell flour is obtained by grinding various shells, such as walnut, pecan, or peanut shells. The product is somewhat spherical, rather than fibrous, in form. Thus, the molded parts obtained have a smoother finish, but lower resistance to impact than those containing fibrous-type fillers.

Cotton flock is usually obtained by processing cotton clippings. Another method is the caustic purification of cotton linters.

Alpha-cellulose is produced by a special alkaline treatment used in the refining sequence in the manufacture of bleached wood pulp. Because of its pure white color and low density, it is widely used as a filler in urea and melamine molding powders.

Sisal fiber is generally used as a mat which is impregnated with a liquid phenolic resin. Prior to impregnation, the strength of the mat is usually improved by a needling process which drives tufts of fiber through the mass. Chopped sisal fibers are also used to increase the impact resistance of phenolic molding compounds.

Chopped paper is usually impregnated with resin before being cut into fragments. Diced resin board is produced from sheet stock made from a suspension of pulp and resin.

Macerated fabric is produced by cutting various types of clean cotton cloth into small pieces.

Lignin fillers may be produced from the bark of trees, such as Douglas fir, or by extending wood flour with derivatives of lignosulfonic acid. Since lignin is the natural binder for cellulose in wood, the use of such products as partial replacement for resins in molding powders is possible.

Soybean meal is prepared by grinding the bean residue after the extraction of oil. When soybean meal is used as a partial replacement for wood flour, the molded parts exhibit poor resistance to moisture.

Keratin products, such as feathers, hoofs, or hog bristles, are usually calcined before use. These products, like lignin, permit a reduction in the amount of resin used in the molding powder.

Nylon, when used as a filler, produces a strong product; however, there may be a problem of shrinkage during molding. Nylon 6/6 is supplied both as a flock and also as a chopped fabric (for higher impact strength).

Naturally occurring *graphite* may be added to molding compounds in order to produce self-lubricating bearings.

Carbon black exhibits little reinforcing action in phenolic resins and actually contributes toward brittleness. Of course, graphite and carbon blacks produce dark molded parts. Molded parts containing graphite have inherent lubricity and have been used for moving parts such as casters. Carbon black is used sometimes in small quantities as a pigment. The use of acetylene black yields molding powders with good electrical conductance.

Asbestos is a naturally occurring fibrous material obtained by cleavage of the mineral chrysotile—a form of hydrated magnesium silicate. Asbestos improves the heat resistance of molding powders.

Mica is obtained from the mineral muscovite, a complex potassium aluminum silicate. This filler is readily wetted by most resins and is compatible with all. It yields a molding composition which possesses excellent electrical and good heat resistance.

Diatomaceous silicia is an amorphous fossil consisting of the remains of diatoms. It has a lower specific gravity than asbestos or mica, but is not quite as effective as these fillers in improving heat resistance and electrical properties.

Glass fibers are produced by the extrusion of molten glass through tiny orifices. Molding compounds containing long-fibered glass have excellent resistance to impact and heat.

Other inorganic compounds, such as *litharge, barium sulfate,* and *chalk,* are seldom used without additional fillers. They contribute special properties such as high density and X-ray opacity.

Compounding techniques

Whenever the filler is available as a readily wettable powder, it is generally mixed intimately in a ribbon blender with approximately an equal weight of resin previously compounded with other ingredients. When a two-stage phenolic resin is used, hexamethylenetetramine is also added as a curing agent.

The other ingredients are usually present in small proportions. The completely mixed formulation is usually passed between steam-heated rolls in order to secure a more intimate mixture and advance the resin. The compounded sheet is removed, cooled, and ground. The ground powder is then passed through sifting screens to remove the fines and tailings.

The portion with the desired screen analysis is then conveyed to a blender to secure large quantities of uniform products.

Some fillers, such as coarse fibers and fabrics, cannot be processed by conventional methods, since the shearing action would destroy the desired fibrous structure. Fillers of this type are usually impregnated with a solution of resin; they are diced, and then chopped into small particles.

Properties of fillers

A critical examination of all known commercially used fillers will show that none is satisfactory on all counts. However, wood flour meets many of the requirements and hence is the most widely used filler in phenolic molding compounds. Where color is considered more important than cost, as in light-colored urea and melamine molding compounds, alpha-cellulose is the principal filler used.

An examination of the empirical values assigned for various fillers in Table II, p. 438, will give some idea of their general usefulness. Since the ideal filler would have a rating of 10 for all properties listed, its total index value would be 90. Under specifications for an ideal filler, impact resistance is listed ahead of cost. However, there are some instances where resistance to heat is considered more important than either strength or cost. In such instances, the danger of drawing erroneous conclusions can be minimized by placing proper emphasis on those properties considered critical for specific applications. Each index value must be weighed in accordance with its relative importance for each use.

With the addition of various fillers, properties can change radically. An unfilled phenolic, for example, has an impact resistance (A.S.T.M. D-256) of 0.25 ft.-lb./in. of notch, while a general-purpose phenolic (wood flour-filled) has 0.30 and a high-impact phenolic (macerated textile-filled), 2.0. Values for other materials are listed in the Plastics Properties Chart.

Typical applications

Molded products made from general-purpose phenolic molding compounds with wood flour filler are those requiring moderate heat and electrical resistance.

Alpha-cellulose, produced by the comminution of alpha-cellulose wood pulp, can be obtained in a wide range of density and fiber lengths. In molding powders, it can be used to obtain marked improvement in impact factor while maintaining pourability and low bulk factor.

Since alpha-cellulose is itself thermally stable to temperatures over 500° F., filled urea compounds are unaffected by continuous exposures to 170° F., while corresponding melamine compounds are good indefinitely at 210° F. Even higher temperatures may be satisfactorily encountered with the darker-colored phenolic compounds.

Alpha-cellulose flock may also be used to good advantage in extending the relatively expensive vinyl resins. Such compounds show excellent nonskid characteristics and resiliency.

Medium-impact phenolic molding compounds containing cotton flock are molded to form washing machine agitators, hair dryer parts, and small industrial wheels. Recently, there has been considerable interest shown on the part of manufacturers of vinyl records to introduce small percentages of cotton flock into the vinyl for reinforcing purposes.

High-impact phenolic molding compounds reinforced with macerated cotton fabric are used to produce heavy-duty industrial parts, such as pulleys and terminal blocks.

Articles requiring good resistance to heat and moisture are molded from compounds which are filled with mica or with asbestos. Because of their exceptional versatility, thermosetting resins compounded with appropriate fillers have been used for the fabrication of thousands of different molded articles. These compounds lack the glamour of some of the newer materials and, like all good "workhorses," are sometimes overlooked until no other satisfactory material is found. However, when they are "rediscovered," these time-tested plastics materials answer a real need.

References

Consult the Subject Index for additional information concerning fillers for molding compounds. Consult the "Bibliography of Books and Magazines," p. 20, for general texts which have chapters on fillers. For sources of fillers, see Directory Index, p. 1078.

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FILLERS FOR POTTING COMPOUNDS

By Harry L. Voorhees

Basic resins for potting compounds, and their application, are discussed in the article on p. 733. These resins frequently require further compounding with a variety of fillers, diluents, flexibilizers, foaming agents, and other materials, if optimum properties are to be obtained.

Fillers: Precipitated or water-ground calcium carbonate, silica, titanium dioxide, zirconium oxide, powdered aluminum, zirconium silicate, chopped glass, asbestos, tabular alumina, fused-quartz powder, mica powder, and other non-reacting materials unlikely to release water or evolve gas during processing are frequently incorporated in casting formulations. In addition to cutting costs, fillers serve several other functions, as follows:

1) One of the most important of these functions is the reduction of the coefficient of thermal expansion of the casting material to approach that of metal inserts. In this way, the setting-up of internal stresses by the differential expansion and contraction of the metal and plastic parts is eliminated and damage to delicate devices or cracking of the plastic is avoided. In general, the extent of reduction of the coefficient will depend upon the type and amount of filler used. The amount of filler that may be used depends, again, upon its type, its specific gravity, and its particle size. These factors influence the propensity of the filler to settle out, causing stratification and resultant variation of the coefficient throughout the casting. They also influence the extent to which the filler increases the viscosity of the system until it no longer flows into tiny interstices. For some filler types, at least, optimum filler-particle sizes and shapes are said to exist.

2) Another important property of fillers in electrical applications is the capacity of the denser materials to improve thermal conductivity of the casting material, and aid in heat dissipation.

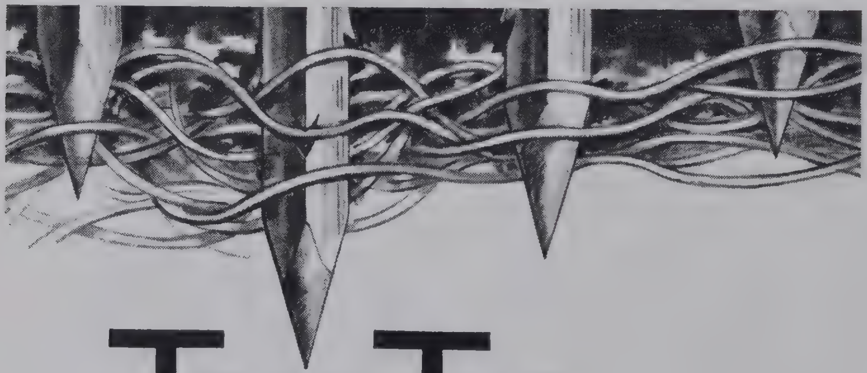
3) Fillers harden cured systems and improve their physical and electrical properties. Electrical grades of mica powder, for example, improve arc resistance.

4) Fillers can be used to impart color and enhance the appearance of components or to provide color-coding for easy identification. Pigments or dyes incorporated in one part of two-component potting systems can serve as an index of thorough mixing.

5) Fillers are useful for modifying the flow characteristics of uncured systems. Thixotropic fillers such as Bentone 38 or Cab-O-Sil are available for the formulation of putty or paste-like compounds useful in encapsulation and sealing work.

For impregnation, on the other hand, low-viscosity systems are desirable in order to eliminate voids which might lead to localized corona with resultant heating and degradation of the surrounding resin. Increased fluidity is also desirable to permit heavier loading with filler, and may be brought about by heating the system or by incorporating *solvents* or *reactive* diluents. Heating will shorten pot life and cause increased shrinkage due to thermal contraction. Solvents must be removed if degradation of final properties is to be avoided—a difficult process and one leading to excessive shrinkage. Reactive diluents such as butyl glycidyl ether, phenyl glycidyl ether, allyl glycidyl ether, styrene oxide, and octylene oxide used in epoxy systems probably provide the best answer. They must be used sparingly, however, if final properties are not to be degraded and shrinkage is to be minimized. Another complication is the propensity of these low-molecular-weight materials to evaporate under vacuum. Lower-vapor-pressure reactive diluents such as butanediol diglycidyl ether should be helpful in such instances.

For information on flexibilizers, see that part of the article on "Potting and encapsulation of electrical components" which appears on p. 736.



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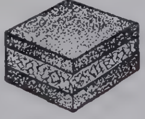

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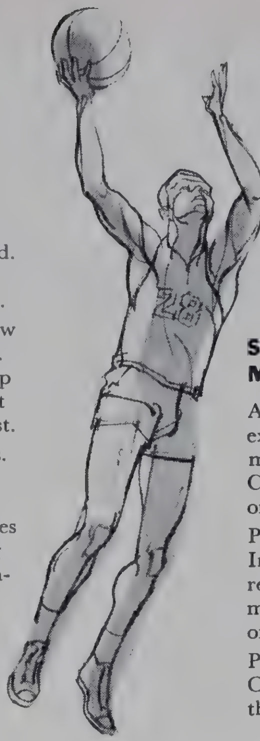

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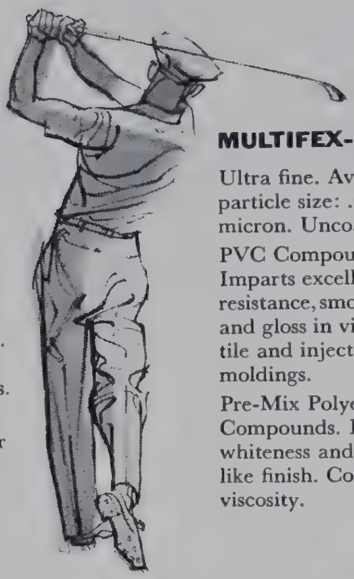

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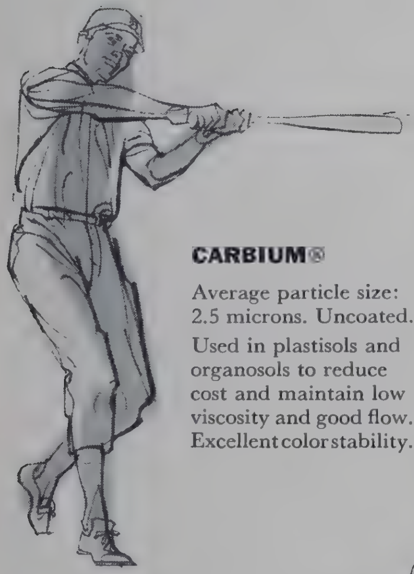

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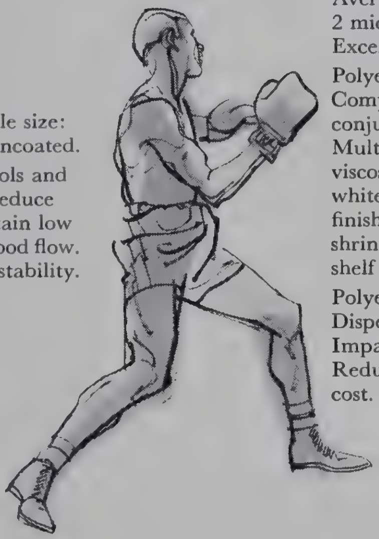

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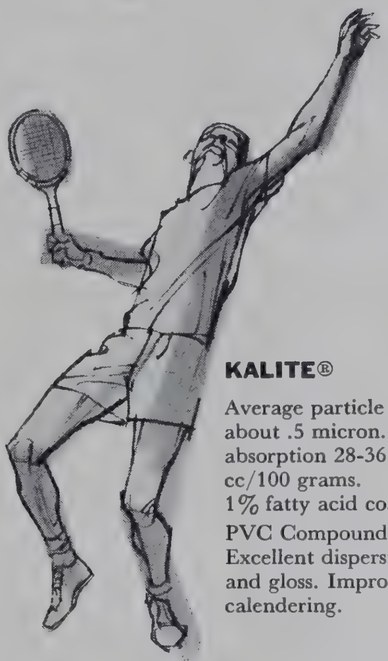

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Fibrous glass reinforcements

By C. J. Gongolas*

Glass in fibrous form is a versatile plastics reinforcing material which in the last decade has experienced an unprecedented growth. This is because fibrous glass imparts to plastics special characteristics which no other reinforcement does. Physical, mechanical, and electrical properties are enhanced in almost all cases.

Basically, fibrous glass reinforcements are filaments blown or drawn from molten state and combined into various forms, offering a variety of physical characteristics and end-use properties.

The formulation from which glass fibers are made is known as "E" glass, denoting electrical grade, and is a low-soda content lime-alumina-borosilicate glass. This formulation is designed to give special fiber-forming characteristics while physical, electrical, and mechanical properties are at their best combined levels.

Glass fibers have high tensile strength (400,000 p.s.i.), relatively low modulus of elasticity (10,500,000 p.s.i.) and high modulus of resilience. In general, only a small percentage of these values is realized and that is due primarily to the surface characteristics of glass fibers. Poor abrasion resistance and chemical resistance, as well as poor bonding of glass-to-resin, make for deterioration of the load transfer from fiber to fiber. This is partly improved by treating the surfaces of the glass for protection against abrasion and/or for better bonding. This treatment is done either at the point of generation of the fibers or, in certain forms, after the fibers have been processed into woven material.

Methods of manufacture

The bulk of the glass fibers used in reinforced plastics are made by 1) continuous drawing by mechanical means as opposed to 2) steam or

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for FILLERS AND REINFORCEMENTS

A low-cost grade of dense-type precipitated calcium carbonate (*Carbium,* Diamond Alkali Co.) is fully adaptable for use as a filler for polyvinyl chloride resins . . . meets all requirements of uniformity, processability, and other stability in all polyvinyl chloride applications where these factors are important.

A coarse weave continuous filament glass fabric (*Dilecto GB-89S,* Continental-Diamond Fibre Corp., subs. of The Budd Co.), bonded with a silicone laminating resin, combines high resistance to flame, heat, arc, and moisture, with good electrical and mechanical properties . . . is intended for terminal, mounting, and spacer blocks; switchgear; electric welders; and similar applications involving arcing and localized or ambient temperatures up to 200° C.

A pre-impregnated parallel fibrous glass material (*Houze Hi Mod,* The Houze Glass Corp.) has flexural strengths up to 274,000 p.s.i. and moduli up to 10.4 million p.s.i. A B-stage resin is applied at the fiber furnace, thereby encapsulating each individual fiber and preserving its inherent strength.

A line of acrylic fiber reinforcements (*AllFab,* The Felters Co.), chemically bound into felts or mats, possesses improved outdoor weathering qualities, better electrical insulating properties, higher resistance to abrasion and the action of various chemicals, and lower weight than other fiber reinforcements . . . the thermoplastic binder used permits maximum draw and elongation without tearing in deep draw applications.

Continuous monofilaments made from pure quartz, twisted into thread and woven into cloth on textile equipment, may be used to reinforce plastics (Lamp Glass Dept., General Electric Co.) . . . when woven into fabric, the monofilaments have the basic properties of glass fabrics, the very high temperature resistance of quartz, and good tensile strength at elevated temperatures . . . greatly improves strength-to-weight ratios and increases the potential pay-load of space vehicles.

Vinylsilane finishes (*A-172,* Union Carbide) on fibrous glass or polyester fiber (*Dacron*) fabric has greatly improved the bond or peel strength between the finished fabric and silicone rubber . . . plays an important role in the performance of aircraft ducting made up of layers of rubber and fabrics. The finish also provides small but significant protection to glass cloth used in silicone resin laminates and does not interfere with the physical or electrical properties of the laminate . . . vinylsilane-treated fillers are more easily wetted with polyester resin, improve physical and electrical properties of molded products.

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*Pittsburgh Plate Glass Co., Fiber Glass Div., 1 Gateway Center, Pittsburgh 22, Pa.

Recent Developments and References were prepared by the editors.

air blowing and 3) flame attenuation.

The steam blowing and flame attenuation methods produce comparatively short lengths of filaments which may be made into mats for heat insulating, surfacing, or air-filtering purposes, and staple yarns.

The continuous drawing by mechanical means forms endless filaments which are combined into strands and later processed into spools. All methods use a basic unit called the "bushing," through which molten glass flows and is attenuated or reduced to the desired diameter. The bushing is a heated metal trough, usually of noble metals in order to withstand the corrosive action of molten glass at high temperatures. At the bottom of the trough multiple small orifices serve as metering devices which let glass flow.

In the case of the continuous drawing, the filaments are gathered into a strand and wound at high speeds onto a "forming tube." The diameter of the filaments is controlled by the temperature of the molten glass and the bushing, the diameter of the bushing orifices, and the speed with which the filaments are drawn. This diameter may be varied and ranges from 0.00020 to 0.00075 inch.

The coating of the glass, which is done immediately after the forming, is one of the most important phases of the process. It is designed to improve the poor abrasion characteristics of the glass filaments and thus protect them from each other. It is also designed to bond the filaments into a strand so that they act as a unit in all subsequent operations. This is accomplished by combining a lubricant and an adhesive or film-former in the coating. Of course, the best lubricant, which will perform its task of minimizing abrasion, interferes with the bonding of the resins and the glass surface. When such strands are twisted, plied, and woven into cloth, the coating must be removed, usually by burning off (heat-cleaning), and sized with a coupling agent which will improve the bond between the glass and the resin. This coupling agent is called the finish. Several finishes are being used, depending on the resin the cloth is to be combined with. (See Table I, right.) Intensive research is being conducted by glass manufacturers to minimize or eliminate the heat-cleaning and sizing operations by modifying the lubricants and film-formers, and incorporating the coupling agents in the coating formulation.

In some reinforcements, e.g., rovings, mats, and chopped strands, a compromise has been made where the abrasion problem is not too serious. A coating or binder is applied on the filaments at the bushing which makes the glass surface compatible with the resin to be used. Most popular are the "chrome" and "silane" binders, which give good physical properties in laminates with several resins.

Depending on the method of molding, the economics of the product, and its desired physical properties, several forms of fibrous glass reinforcement may be used.

Rovings and chopped strands

These are low-cost reinforcements which are made from strands sized at the bushing and consequently ready for combination with the resins.

Rovings are wound in multiple strands (usually 60) to form a package which may be easily shipped to the user. They may be used as unidirectional reinforcement in rod stock or in preforming of large shapes. For the most effective performance, they may be varied in the formulation and amount of binder for "softness" or "hardness," as well as absence of static. When tensioned evenly they may be pre-impregnated with resin for winding cylindrical shapes where high hoop strength is desired, e. g., pipe, rocket engines, etc. When chopped in place, they may be used instead of the more expensive form of mat in the manufacture of corrugated and flat translucent sheets. More recently, with the development of several strand spraying methods[1], rovings may be used to form large shapes against open molds—in competition with the hand lay-up method that uses mat. Molding compounds may also be made by pre-impregnating and chopping the rovings.

An interesting new development in glass rovings used in connection with the various spray guns or depositors is the inclusion of one colored glass tracer which

TABLE I: Types and sources of finishes for fibrous glass*

Finish	*Used with*	*Sources*[1]
112 (completely desized)	Silicones	UM, CMS, HG, FFG OCF, JPS, F, E, M
111 (partly desized)	Melamines	HG, CO, IVI, OCF, JPS
136	Polyesters, some silicones	UM, HG, CMS, JPS
Volan-A	Polyesters, phenolics, epoxies	CMS, HG, UM, OCF, FFG JPS, F, E, EFG, PPG
Garan	Polyesters	HG, UM, M, JPS, LOF
114	Polyesters	CMS, HG, UM, OCF JPS, E, F, FFG
A-1100	Epoxies, phenolics, melamines	HG, OCF, UM, JPS F, E, CMS, LOF, FFG
NOL-24	General-purpose	UM
T-31	General-purpose	JPS
301	Polyesters (triallyl cyanurates)	OCF
A-172	Polyesters and silicone resins	CMS, E, FFG, F, HG M, OCF, JPS, UM, MO PPG, FG

*This table was prepared by C. E. Hoover and R. Sonneborn, Owens-Corning Fiberglas Corp., 598 Madison Ave., New York, N.Y.

[1] Code for sources: CMS—Coast Mfg. Co., Livermore, Calif.; CO—Cordo Chemical Co., Norwalk, Conn.; HG—Hess and Goldsmith Co., a member of Burlington Industries, New York, N.Y.; IVI—Irvington Div., Minn. Mining & Mfg. Co., Irvington, N.J.; UM—United Merchants Industrial Div., New York, N.Y.; OCF—Owens-Corning Fiberglas Corp., New York N.Y.; M—Menardi, Culver City, Calif.; JPS—J. P. Stevens, New York, N.Y.; F—Flightex Fabrics, New York, N.Y.; E—Exeter Mfg. Co., Exeter, N.H.; LOF—Libby-Owens-Ford, Toledo, Ohio; FFG—Ferro Corp., Fiber Glass Div., Nashville, Tenn.; MO—Modiglass, Inc., Florham Park, N.J.; PPG—Pittsburgh Plate Glass Co., Pittsburgh, Pa.; FG—Fiber Glass Industries, Inc., Amsterdam, N.Y.

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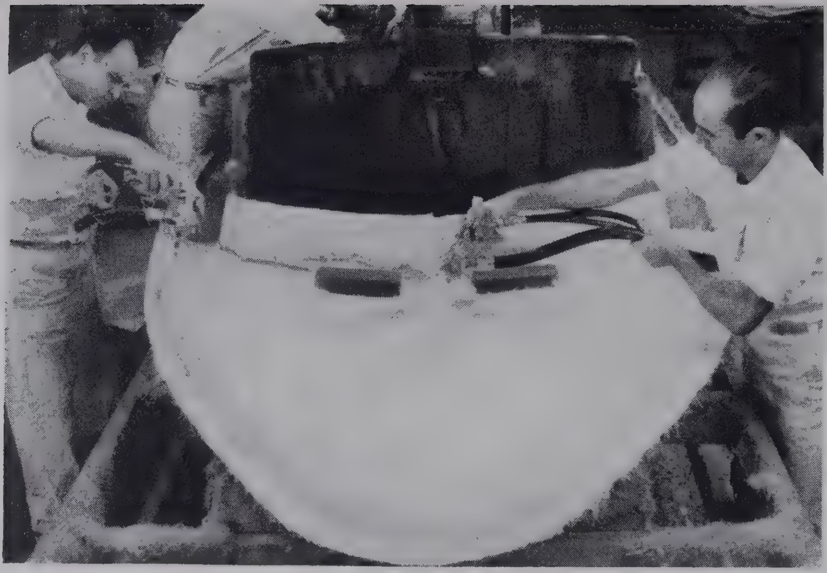
[1] Rand Depositor



MAJOR MARKET for fibrous glass in mat form is boat building; here mat is laid up by hand and polyester resin is sprayed on. (U.S. Rubber)

helps the operator control the distribution of the material deposited and in some respects, the thickness of the laminate. These tracers are all glass and the colors are not soluble in the polyesters used.

Chopped strands are made from the same strands from which the roving is wound but they are cut into definite lengths of ¼, ½, and up to 2 or 3 inches. Extensive use of fibrous glass chopped strands is being made in premix molding. Resin (usually polyester or diallyl phthalate), catalyst, filler such as calcium carbonate or calcium silicate, and chopped glass fibers, mostly in ¼ and ½ in. lengths, are mixed in a sigma or Z-blade mixer to a uniform consistency. Parts are then molded in compression molds at 500 to 1000 p.s.i. Fast cycles are possible by varying resin, filler, and reinforcement formulations. For some applications, other low-cost reinforcements such as sisal and asbestos are used with glass fiber.

Spun roving

Spun roving is a reinforcement made up of one continuous strand looped and wound into a roving-like form. Similar to conventional roving, it can be chopped up to be used in some forms of molding compounds.

Reinforcing mats

Mats made of chopped or continuous fibrous glass strands are a convenient form of reinforcement for flat or nearly flat shapes, especially those molded under atmospheric pressure.

Mats are usually made by chopping the basic strands into 2 in. lengths and laying or sucking them onto a moving belt. The thickness of the resulting mat (described in terms of oz./sq. ft.) can, of course, be varied. The mat is held together with a chemical binder which may be of low or high solubility, depending on the final use. Some mats can be mechanically "needled" together for faster wetting.

Still another type of mat, known as a "swirl" mat, is made from continuous strands which are laid in a random fashion. This type of mat conforms more easily to curved surfaces. Mats are a more expensive form of reinforcement.

Milled fibers

When it is desirable to have lengths of less than ¼ in. of chopped strands, the product that is currently being offered is milled fibers, usually hammer-milled into small 1/32 to 1/8 in. lengths. In this form, the strands lose their identity and separate into filaments. Up until recently, milled fibers were hard to handle and dispersed easily because they tend to form small nodules. A new type of milled fibers is now available which has largely overcome this problem and may be blended in a dry or wet mix without difficulty. Milled fibers find use in casting resins and putties or caulking compounds, where they contribute to dimensional stability and minimize crazing and cracking.

Twisted yarns

Heat-treated twisted yarns are being used in the manufacture of reinforced plastics to a much smaller extent than rovings or mats. Their main use is in the manufacture of woven material such as tapes, braids, sleeving, and industrial or decorative fabrics. Warp beams of several hundred parallel yarns are also used, but to a very limited extent.

Yarn nomenclature

The nomenclature of fibrous glass yarns differs from that used for other types of textile fibers because of the large variety of nearly identical yarns that are produced. The complete nomenclature consists of two basic parts—one alphabetical, the other numerical. A series of three letters describing the basic glass strand is used in combination with numbers that identify the standard yarn count and yarn construction; for example, ECD 450-3/2. The first letter to be used defines the glass composition—"E" for electrical and "C" for chemical. The "E" glass formula, which is used most often, has excellent electrical properties while the "C" glass is compounded for chemical resistance and is used predominantly for certain types of staple fibers. The second letter indicates the type of fiber—"C" for continuous filament and "S" for staple fibers. The third letter defines the average fiber or filament diameter from which the yarn is made. The numerical values for the third letter are as follows:

D	0.00023 in.
E	0.00028 in.
F	0.00033 in.
G	0.00038 in.

Thus the letter symbol, ECD, given above, indicates a yarn made from the electrical glass formula in continuous filament form with an average filament or fiber diameter of 0.00023 inch.

The numbers following the letters indicate the hundred yd./lb. and yarn construction. The first number (count), 150, 450, 900, etc., is 1/100 of the approximate yardage of basic strand or sliver in one pound. Thus, yd./lb. is easily computed by multiplying this number by 100. This second series of numbers following the count number (—1/2, —3/0, —4/4, etc.) designates the number of plies in continuous filament yarns.

The first digit in this series shows the number of original singles (strands) twisted and is separated by a diagonal line from the second digit that indicates the number of these units plied. The total number of strands is determined by the products of these two numbers (0 is multiplied as 1). Plies in staple fiber yarns are shown by a single number separated by a diagonal from the count number.

Surfacing and overlay mats

The problem of the surface smoothness of fibrous glass laminates is directly connected to the nature of the stranded form of the fibers. When a preformed matched metal molding is removed from the mold, the surface shows the strands in a random pattern which is not always desirable. Furthermore, the strands on the surface form the openings through which the action of the water or other chemical usually begins, attacking the bond between the resin and glass.

A partial answer to the problem has been the use of surfacing or overlay mats made entirely of filaments rather than strands, bonded together with suitable binders (hard and stiff for surfacing, soft and pliable for overlay). These mats provide an area where an excess of resin may form a film protecting the laminate and smoothing the surface. Their applied cost limits their use and several companies are investigating alternate methods of overcoming the problem.

Woven fabrics

Fabrics made of twisted and plied yarns are a highly controlled form of reinforcement and therefore one which lends itself to a variety of applications where high strengths in several directions are desirable. When heat-cleaned and resized with suitable coupling agents, fabrics can be used for hand lay-up or press molding. The type of product determines whether a glass fabric is used in lieu of other forms of reinforcement. In several mili-

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HYDRITE-FLAT "D"	4.5	80.2-83.8	4.2-5.2	0.15
HYDRITE-121	1.5	83.0-84.5	4.2-5.2	0.10
HYDRITE-R	0.77	85.0-86.5	4.2-5.2	0.02
REA-45	4.5	80.2-83.6	6.5-7.5	0.15
REA-15	1.5	83.0-84.5	6.5-7.5	0.10
REA-7	0.77	85.0-86.5	6.5-7.5	0.02

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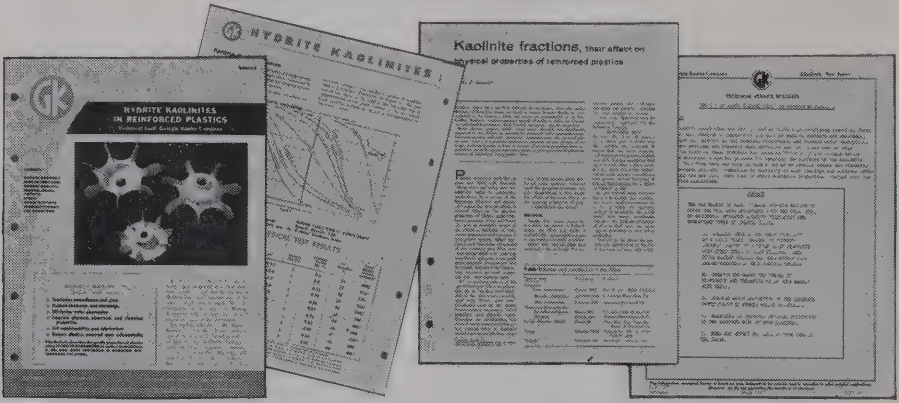
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tary applications, glass fabrics are used exclusively, because of their dependability and uniformity.

Woven rovings

In the past few years, fabrics woven of rovings have become popular in certain applications where strength plus bulk are desired in a laminate. Woven rovings or roving cloths fall in the area in between standard fibrous glass fabrics and mat with respect to cost and strength. They come in several weaves and are versatile in the shapes in which they may be molded. Since they lend themselves well to the molding of large shapes such as boats, tanks, etc., the hand lay-up method uses woven rovings most extensively.

The choice of the proper type of glass reinforcement is the result of a careful study of the product to be made. Generally speaking, large shapes of limited production (tens or hundreds of units) are made by the hand lay-up method using such reinforcements as woven fabrics, woven rovings, or mat, depending on the strength limitations. Spray-on methods may also be used with proper controls.

When the number of units to be made runs into thousands, the use of roving with matched-metal molds and large presses can be justified by lower costs per unit.

For unidirectional reinforcement, rovings, and to an extent, yarns and some forms of woven fabrics, may be used.

FIBROUS GLASS VEIL MAT can be laid over preform (as below, for an outboard motor shroud) to smooth surface, improve appearance, and strengthen bond between resin and glass. (Photo, Outboard Marine)

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On a cost-per-pound basis, of course, the woven fabrics are the highest; on a strength-per-pound basis, however, they compete equally with other forms of reinforcements.

It is therefore important that the designer be thoroughly conversant with his product, the reinforcements available, and the methods of molding or fabrication for a successful application.

References

Consult the Subject Index for additional information concerning fibrous glass fillers. For sources of fibrous glass for reinforcements, see the Directory Index, p. 1078.

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Asbestos reinforcements

By M. S. Badollet*

The fibrous mineral silicates, known by the broad term asbestos, are unique in their physical and chemical properties. Each variety of asbestos has been fairly well evaluated in commercial products as fillers and reinforcements, and their order of importance in usage may be listed as chrysotile, crocidolite, amosite, anthophyllite, and tremolite.

The availability of asbestos, degree of purity, and cost are important factors for a manufacturer and he in turn must obtain sufficient advantages to warrant use of this mineral when compared with other reinforcement materials.

Chrysotile. Chrysotile, the most widely used industrial asbestos, is a hydrous magnesium silicate having a sheet- or layer-like structure somewhat like the kaolin (1)[1] group and may be represented on a unit cell basis as $Mg_6(OH)_8Si_4O_{10}$.

Fiber diameters depend upon the degree of fiberization, which varies from 40 microns and larger to 350 Angstrom units and less, thus making asbestos the smallest cross-section fiber known. Fiber lengths were originally controlled by their growths in the fractures, fissures, or openings in the ultrabasic rocks. However, these lengths are later reduced by milling; hence they appear for industrial use in lengths from ¼-in. to 1 in. for the longer fibers down to microscopic in length.

The flexibility of chrysotile also varies from excellent, for the soft varieties, to poor for the harsh varieties.

Measurements (2) show that chrysotile has the greatest surface areas of any known fiber. Density measurements of pure chrysotile (4) have been reported from 2.53 to 2.58.

Chrysotile (2) in the presence of water has shown an alkaline pH as high as 10.3. Other pH values have been reported in the range of 9.2 to 10.1. Amphibole asbestos fibers (amosite, anthrophyllite, crocidolite, and tremolite) are lower in pH values than chrysotile, which is of the serpentine variety. For example, amosite has a 8.5 pH, anthophyllite 7.0, and crocidolite 8.4. If the high alkalinity of chrysotile is objectionable, one of the amphibole fibers may be satisfactory if the strength is good.

Physical properties of asbestos fibers (5), *spinning grade*: The physical and chemical properties of asbestos fibers in general sometimes serve as a guide in the proper selection of asbestos for use in laminates, felts, or cloths. (See Table of Characteristics, p. 450.) The ideal fiber would have the highest volume resistivity, the lowest total iron, the lowest magnetic rating, the lowest conductivity, and the lowest NaCl equivalent. Amphibole fibers are usually better than chrysotile in terms of volume resistivity and conductivity, but they also lose considerable length in processing. The action of temperature upon the amphiboles (3) is less than upon chrysotile since the amphibole fibers have less water of hydration. The fusion temperature of chrysotile is approximately 2770° F.; the amphiboles vary from 2180° F. for crocidolite to 2675° F. for anthophyllite.

Mineral acids are more destructive than organic acids (3) to all asbestos fibers. These acids are more active on chrysotile than on the amphiboles.

Crocidolite may vary in specific gravity from 3.2 to 3.3, amosite from 3.1 to 3.25, anthophyllite from 2.85 to 3.1, and tremolite from 2.9 to 3.2 depending upon the degree of purity.

Tensile strengths reported for asbestos fibers have varied with investigator and type of equipment. Recently reported values showed tensile strengths (7) higher than those previously given. Fibers of amosite one centimeter long from the Transvaal were reported to have an average tensile strength of 192,000 p.s.i.; crocidolite from the Cape Province, 540,000 p.s.i.; chrysotile from Arizona, 312,000 p.s.i., and chrysotile from Thetford, Canada, 355,000 p.s.i. These values are probably based upon pieces of crudes rather than milled fibers. However, they show that asbestos fibers are exceedingly strong and can be quite valuable in plastics.

Use of asbestos in plastics

Cold-molded plastics: In cold-molded plastics (6) the function of asbestos is to reduce molding costs; make the molding possible by controlling the flow of material under pressure while it is in the cold mold; improve mechanical properties; increase hardness; decrease molded shrinkage; increase heat and fire resistance; facilitate ejection from the mold; and improve handling and movement of the uncured moldings without danger of deformation or warpage. Cold-molded products of the bituminous type are sometimes loaded with as much as 85% of asbestos. The grades of asbestos used in the cold-molding field are described as floats and shorts. Their physical properties should be the guide in selection.

Thermoplastics: In thermoplastics (6), asbestos increases heat resistance and compressive strength; improves hardness, burning rate, and arcing resistance; and adversely affects the specific gravity, translucency, appearance, and color. It also reduces cost and tendency to cold-flow, with resultant deformation and warpage. The hardness improvement is only moderate.

Asbestos, especially the light-colored fibers, can be used in moderate percentage in the manufacture of thermoplastic molding or calendering materials based on ethyl cellulose, vinyl chloride acetate, vinyl chloride, and polyethylene.

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* Section Chief of Asbestos Fibers, Johns-Manville Research Center, Manville, N. J.

[1] Numbers in parentheses link to Special References on p. 450.

Thermosetting plastics: In thermosetting plastics (6), chrysotile asbestos has many advantages: available in large quantities at moderate cost; of fibrous structure; easy to process and mold in compound form; retains the binders; inert to reactions from rolling, molding, and curing; permits use of high percentages (65 to 70%) in manufacture; imparts toughness; retards burning rate; supplies heat and fire resistance; increases hardness; and reduces the natural shrinkage of the moldings. Molding temperatures higher than 450° F. can cause blistering due to partial release of water from the chrysotile asbestos. Since chrysotile asbestos has an alkalinity of 9.2 to 10.3 pH, it is objectionable for use in urea formaldehyde resin; for most resins, however, this fiber alkalinity is not bothersome.

Asbestos reinforcements: For many years, asbestos shorts or floats were used in molding compounds and only small quantities of longer fibers were used in felts and laminates. During recent years more emphasis has been placed on asbestos either as a loose fiber or in the form of felts, mats, or cloths. The advent of newer resins and improvement of older resins have given added life to this industry.

Long length chrysotile as a loose fiber or as a mat or felt in combination with crocidolite fiber, when impregnated with phenolic resin, can be molded at low temperatures and impart good strength, good resistance to acids, and heat resistance to about 400° F. These felts have been used successfully in the manufacture of boats, plastic wings for aircraft, tanks, gears, bench tops, and similar products.

Laminates: Laminated plastics may be defined as multiple layers, plates, or sheets of materials impregnated by a resin (usually thermosetting) and pressed into one piece. The amount of resin depends upon the degree of impregnation required to produce the proper degree of reinforcing. A highly impregnated material will possess decreased density and improved resistance to moisture and delamination.

The common resins used in laminates are the phenolics, melamines, epoxies, silicones, and polyesters. Table I, below, shows the properties of laminates made with these resins with asbestos reinforcement in the form of fabric or paper.

Forms of asbestos: Asbestos is available in various forms such as loose fiber, rovings, yarns, papers (commercial or Quinterra), felts, cloths, and mill-

TABLE I: Asbestos in laminates

Property	*Phenolic laminates*		*Melamine-formaldehyde laminates*	*Silicone laminates*
	Asbestos fabric	*Asbestos paper*	*Asbestos paper-fabric*	*Asbestos fabric*
Laminating temp. °F.	300-350	300-350	270-320	350-400
Laminating pressure, p.s.i.	1000-1800	1000-1800	1000-1800	30-2000
Specific gravity, D792	1.55-1.80	1.65-1.83	1.75-1.85	1.75
Specific volume, cu.in./lb., D792	17.8-15.4	16.8-15.1	15.8-14.9	15.8
Tensile strength, D638, p.s.i.	10,000-12,000	5,000-15,000	6,000-12,000	—
Modulus of elasticity in tension, D638, 10^5 p.s.i.	3.5-15	—	16-22	—
Compressive strength, D695, p.s.i.	30,000-40,000	40,000	27,000-50,000	40,000-50,000
Modulus of elasticity in compression, D695, 10^5 p.s.i.	7	5	—	—
Flexural strength, D790, p.s.i.	10,000-35,000	15,000-30,000	12,000-24,000	12,000-16,000
Modulus of elasticity in flexure, D790, 10^5 p.s.i.	12	—	—	—
Shear strength, D732, p.s.i.	19,000-21,000	9,000-13,500	13,000-17,000	—
Modulus of elasticity in shear, 10^5 p.s.i.	—	—	—	—
Impact strength, Izod, D256, ft.-lb./in. of notch	3.5-5.0	0.7-1.9	0.75-4	6-9
Bond strength, D952, lb.	1,500-2,200	600-2,000	800-1,500	—
Hardness, Rockwell, D785	M70-M115	M90-M110	M110-M118	—
Thermal conductivity, C177, 10^{-4} cal./sec./sq.cm./1° C./cm.	4.6	—	—	—
Thermal expansion, D696, 10^{-5}/°C.	1.7-2.5	1.0-1.6	—	—
Resistance to heat (continuous) °F.	275	275	225-275	>480
Heat distortion temp., D648, °F.	>320	>320	—	>400
Dielectric str., short time, ⅛ in. thickness, D149, volts/mil	50-100	160-250	50-150	50-150
Dielectric str., step by step, ⅛ in., thickness, D149, volts/mil	50-75	120-200	60-120	50-100
Dielectric str., step by step, || to lamination, KV/in.	5-15	4-25	7	—
Dielectric constant, 10^3 cycles, D150	7.5	7.0	—	—
Dielectric constant, 10^6 cycles, D150	5.5-7.0	5.2	8.0-9.6	—
Dissipation factor, 10^3 cycles, D150	0.06-0.10	0.15-0.20	—	—
Dissipation factor 10^6 cycles D150	0.10-0.15	0.08-0.14	0.12-0.22	—
Arc resistance, D495, sec.	Tracks	Tracks	—	—
Water absorption, 24 hr., ⅛ in. thickness, D570, %	0.3-2.5	0.4-2.0	1.0-5	1.0-1.5

Table of Asbestos Fiber Characteristics

Source	*Volume resistivity** Megohms/in.	*Total, iron* %	*Magnetic rating*	*Conductivity of aqueous extract* Megohms/cm.	*NaCl equivalent* %
Chrysotile					
Rhodesia (Africa)	0.06-0.39	1.0-3.1	0.17-1.9	117-290	0.0056-0.13
British Columbia (Canada)	0.05-0.08	1.6-2.3	0.72-1.3	322	0.0154
Barberton (Africa)	0.03	0.15-1.29	0.06-0.3	184	0.09-0.11
Quebec (Canada)	0.008-0.17	2.2-4.3	0.8-6.7	186-559	0.089-0.266
Amphibole					
Amosite (Africa)	0.78-1360	27.9-30.8	0.17-0.33	73.9-160	0.035-0.076
Crocidolite (Africa)	0.56-1.42	25.3-28.2	0.4-5.4	74-124	.0035-0.059
Anthophyllite (U.S.)	19.3	6.4	0.06	115	0.0055
Anthophyllite (Mozambique, Africa)	6.4	5.48	0.6	23	0.022

*Humidity conditions, 16 hr. at 75° F. and 91 RH.

boards. Any of these may be impregnated by the standard methods and/or laminated to produce the desired product. Asbestos in the form of loose fiber, paper, or felt is now being used in plastics pipe, with promising results.

In the manufacture of asbestos laminates it is important to select the proper kind of asbestos, whether it be in the form of loose fluffy fiber or paper, mat, roving, or cloth.

Resin impregnation for either high-pressure or low-pressure laminates can be accomplished by appropriate conventional methods. Some of the advantages of asbestos in laminates are:

(1) The wettability of asbestos fiber by resins is very good during the impregnation cycle.

(2) Asbestos-resin laminates have good heat resistance for short periods of time at temperatures of 700 to 6000° F.

(3) They possess good resistance penetration by gases.

(4) Asbestos in combination with other fibers in laminates increases resistance to water penetration.

(5) Asbestos laminates have very good machineability, and can be threaded or tapped.

Recent developments in asbestos fibers for use in plastics: The benefits to plastics of asbestos fibers of the chrysotile variety have heretofore been penalized somewhat by the presence of grit, fines, and crudy fiber bundles not properly opened and by the greenish-gray color. These impurities are reflected in the final products by lowered strength and some sacrifice in appearance.

Recent developments at the Johns-Manville Research Center in cleaning of fibers have greatly improved the color, increased the degree of purity, and enabled the asbestos mines to produce higher grades of clean fibers from some of the lower-grade fibers, and at the same time to present new fiber grades to the plastics industry. The surface areas of the cleaned fibers, when expressed in terms of cm.^{2}/g. show that the cleaned fibers have increased surface areas for resin impregnation; hence have greater strength potential.

In three grades investigated, the color of the cleaned asbestos has been changed from greenish-gray to white by a large reduction in fines. Such fibers have been used experimentally in phenolics and polyester resins and have shown unusual promise. These fibers are now being offered for test purposes prior to a regular production at the mines in Canada.

For example, the three grades of chrysotile asbestos have been incorporated in a phenolic resin with a 60% loading and molded at 350° F. and 2500 p.s.i. for seven minutes. The flexural strength and flexural modulus values showed considerable improvement because of the cleaning. (e.g., on one grade, flexural strength rose from 14,700 p.s.i. to 19,400 p.s.i. after cleaning; flexural modulus at 10^6 p.s.i., rose from 1.89 to 2.01; on another grade, the rise was from 10,600 to 17,800 and 1.67 to 2.00.) Since straight molded specimens can be so markedly improved by use of cleaned fibers, their use in laminates should be attractive.

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Consult the Subject Index for additional information concerning asbestos reinforcements. For sources of reinforcing materials, see Directory Index, p. 1078.

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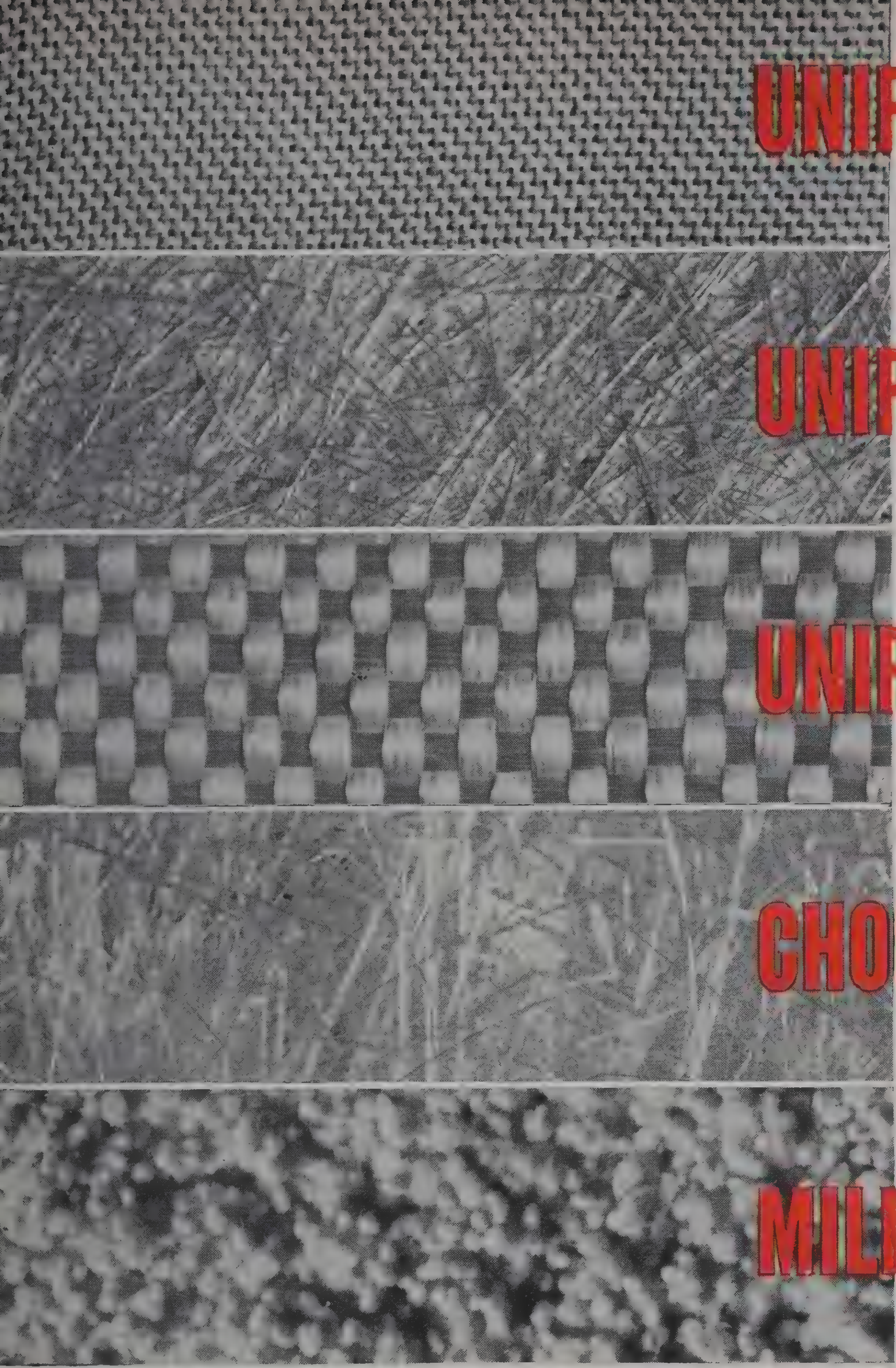

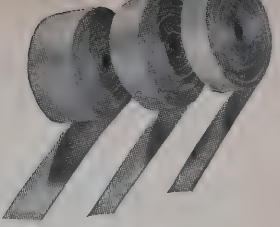

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Synthetic and cellulosic fibers

By H. R. Schwarz*

Synthetic and cellulosic fibers—in nonwoven or fabric form—play an important role in the design of high-pressure or low-pressure laminates. The properties of the individual fibers which are commonly used for these applications are shown in Table I, p. 453.

High-pressure laminates: Cotton is the most important raw material used today for those high-pressure laminates requiring good mechanical properties such as high-impact strength, superior bond strength, and good machining properties. The fibers possess the very desirable combination of good strength and relatively low extensibility. They have the additional advantage of widespread availability and low cost.

Cotton fabrics are generally supplied as grey goods, that is, as they come from the loom, and are not subject to any wet finishing operations. However, they may in some cases be supplied desized or "purified." Desizing consists of removing the starch added to the warp to assist in the weaving operation, as well as the natural oils and waxes inherent in the cotton fiber. The term "purified" is used to denote fabrics which, in addition to being desized or scoured, are bleached and thoroughly washed by water to remove any salts or electrolytes that might have a detrimental effect on the properties of the finished laminate.

Other textile fibers, notably nylon, have special properties that make them suitable for many useful laminated products. Nylon, for example, contributes to the laminate good electrical insulating properties, high-impact strength, and resistance to bacterial attack. Rayon has found only limited uses in the high-pressure laminating field but high-tenacity rayon has been used for certain applications where high-tensile strength is a factor. Acrylic fibers have also been used for electrical laminates.

Low-pressure laminates: Glass fiber is still, by far, the most important textile raw material in this field, whereas cotton has found few, if any, commercial applications, other than as an overlay material. On the other hand, filament nylon fabrics are being used successfuly as reinforcements for low-pressure laminates for military aircraft applications. Nonwoven Dacron[1] batts used for reinforcing polyester and epoxy resins are said to contribute good abrasion resistance, in addition to improved electrical properties, more flexibility, and lighter weight. They are particularly suitable for the molding of deep-draw laminates since they readily conform to even the most complicated shapes.

A new development has been the use of Dynel[2] fabric overlays for glass-reinforced laminates: these overlays greatly improve resistance to abrasion, chemical attack, and weather. Acrylic fiber veils or overlays have also been used to provide an extremely smooth finish in automotive applications.

Acrylic, polyester, and nylon fibers are further being adapted as overlays to various materials-handling applications and end-products demanding good corrosion resistance. Synthetic fiber veil-covered surfaces offer improved chemical resistance, ultraviolet light resistance, good dielectric factors, and a harder surface.

Influencing factors

There are many factors involved in the selection of a textile fiber and fabric structure for a plastics laminate.

It should be recognized at the very outset that the fiber itself is the important element of the fabric contributing to the strength of a laminate. When a continuous filament yarn fabric is used as reinforcement, the tensile strength of the laminate is influenced directly by the yarn strength. In the case of a laminate reinforced with a spun staple yarn fabric, on the other hand, neither the strength of the yarn nor the fabric itself has a direct bearing on the tensile strength of a laminate. It is the strength of the individual fibers which is the significant factor in the strength of the laminated product. The fibers in the spun yarn structure are surrounded by the resin which prevents them from shifting when stresses are applied to the laminated stock. Thus, the ultimate strength of the yarns themselves is never realized.

Another important factor having an effect on the laminate strength is the elongation of the fiber. Assuming that elongation characteristics of both the fiber and the resin are approximately the same, it is the fiber strength that is the determining factor within the limits of the effective adhesion between the fiber and the cured resin. To illustrate the importance of both strength and elongation in laminate strength properties, consider high-pressure laminates reinforced with spun nylon fabric. The tensile strength of nylon-base laminates is not as high as that of laminates reinforced with cotton fabrics. For, despite the higher strength of nylon, the fiber's lower modulus of elasticity does not permit the superior strength of the fiber to be fully utilized when incorporated in a rigid plastic structure. On the other hand, the fiber tenacity has a direct influence on the high impact strengths pos-

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*Wellington Sears Co., Inc., 111 W. 40th St., New York 18, N. Y.
References were prepared by the editors.

[1] Trademark of E. I. du Pont de Nemours & Co. (Inc.), for polyester fiber.

[2] Trademark of Union Carbide Corp., for acrylic fiber.

TABLE I: Properties of textile fibers

COTTON'S natural fiber twist enables spinning of strong yarns. Cotton is durable, absorbent, resistant to stretching and heat; it bulks and insulates well, has high wet strength. Resistance is low to acids and mildew, but high to alkalies and solvents.

RAYON, a regenerated cellulose in staple or filament form, is industrially most important in *high-tenacity* form, with outstanding qualities of high strength combined with light weight. Many of its other properties are similar to those of cotton, but wet strength is lower.

FORTISAN[1] is a strong filament yarn of oriented and saponified regenerated cellulose. The new, highly oriented "Fortisan-36" has exceptional strength, stretch resistance, and dimensional stability. Chemical and other characteristics resemble cotton.

NYLON is a chemically synthesized organic fiber, both staple and filament, available in high-strength forms. It has very high tenacity, wet or dry; excellent abrasion- and flex-resistance; toughness; elasticity; resistance to heat and alkalies; excellent electrical qualities.

ORLON[2] acrylic staple fibers are light, strong, resilient, dimensionally stable, low in moisture absorption and are nonconductors of electricity. They show good resistance to heat, strong acids, mildew, bacteria, ultra-violet rays, and atmospheric effects.

DYNEL[3], staple fiber of vinyl and acrylic origin, has many properties similar to Orlon. Though sensitive to heat, Dynel has excellent resistance to strong alkalies as well as acids, and will not support combustion.

DACRON[2], polyester staple fiber, is water-repellent, quick drying, dimensionally stable, with good electrical properties. It has good strength, flex life, and shape retention, and resists abrasion, heat, and many chemicals.

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[1] Trademark of Celanese Corp. of America.
[2] Trademark of E. I. du Pont de Nemours & Co. (Inc.)
[3] Trademark of Union Carbide Corporation's acrylic fiber.

sessed by the laminates which are reinforced with spun nylon fabric.

Fabric specifications covering textile materials for laminating purposes generally include minimum breaking strength requirements. One of the principal reasons, of course, is to insure uniformity of material. Fabric breaking strength can be easily determined by any textile laboratory. Provided minimum strength values are met in addition to other specification requirements, it is a definite indication that the fabric in question is up to standard.

Generally, plastics produced by laminating techniques are rigid, having a high modulus of elasticity. Accordingly, stretchability and resiliency normally associated with fabric structures formed by the interlacings of twisted yarns are not factors affecting the properties of the laminated material. These fabric characteristics, however, are significant in the case of textiles for postforming stock. Nevertheless, the particular form in which the fibers are introduced to the resin does have an influence on the ultimate properties of the laminate.

Types of fabric

Nonwoven fabric: Nonwoven fabrics or mats are generally made with random fiber distribution and bonded with resins which are compatible with those used in the laminating process. Laminates made from the random nonwoven material have impact, flexural, and tensile strengths just as high in the diagonal directions as in the usual machine and cross-directions.

Nonwoven fabrics are used in the manufacture of laminated products requiring sharp projections or edges, mirror-like machined surfaces, and superior mechanical strength. An early application was the noiseless gear for electric clocks. The balanced strength characteristics of laminates with random fiber reinforcement made it possible to produce fine-toothed gears without weak spots in the teeth. High-speed machining of the laminates without damage was made possible.

Another good example of the unusually good mechanical properties of laminates reinforced in this manner is the textile bobbin head. Tests have shown that heads fabricated from these laminates have nearly twice as much impact-fatigue resistance as the next strongest type (paper-and-canvas-reinforced).

There has also been some activity in the use of papers based on synthetic and cellulosic fibers for reinforcing laminates, but most of the work in this area is still largely in the experimental stage.

Woven fabrics: The density and positioning of the individual fibers in the fabric structure must be considered in developing the optimum laminate to be used for a given application.

Fiber in fabric form has certain advantages which are utilized in laminating production.

Probably the single most important factor is the extremely uniform distribution of the fiber in woven fabrics. This high degree of uniformity enables the plastics manufacturer to combine many layers of varnished cloth together to form a laminate having a homogenous structure. Furthermore, fabric has the advantage of mechanical strength, enabling it to be processed readily, without damage, by continuous methods.

Generally speaking, the laminating varnish has a better opportunity to penetrate the more porous structure of spun staple yarns than the more compact and denser filament yarns, especially in the case of the heavier-weight fabrics, In many cases, economic considerations necessitate the use of comparatively heavy fabrics for mechanical laminates, because of their lower cost per pound.

The amount of yarn twist has a definite bearing on the degree of resin penetration. Fabric woven from softly twisted yarns, although not necessarily strong from a textile standpoint, nevertheless allows more resin to penetrate the fabric structure. This results in a stronger laminated product. Another influencing factor on the properties of fabric-base laminates is yarn crimp. Highest tensile strengths are realized by having the fibers lie as flat as possible in the plane of the laminate. In this position the full reinforcing effect of the individual fibers can be utilized to the best advantage. On the other hand, fabrics with a high yarn crimp often will tend to increase the shear strength of the laminate.

The effects of the various components must be carefully considered in the selection of a fabric construction for a particular end-use. In the majority of cases it is desirable to use a fabric having an equal distribution of strength in the warp and filling in order to obtain balanced strength characteristics in the laminated product. By cross-laminating, however, it is possible to use fabrics with unequal strength distribution and still obtain laminates with balanced properties. For certain applications it may be advantageous to have the strength largely in one direction. When this happens to be the case, so-called unidirectional fabrics are employed.

The bond strength of laminates, (which means the adhesion between the fabric plies), is affected to an important degree by the surface characteristics of the fabric. A softly twisted spun yarn construction, presenting a fibrous surface and a high degree of fabric "pebble" or surface texture, results in an interlocking effect when the fabric layers are combined during the laminating process by means of heat and pressure. At the other extreme, a smooth surface, finely-woven fabric made from continuous filament yarns may have a tendency to delaminate easily. Therefore, a fabric of the latter type should not be used for those applications requiring a high degree of bond strength.

The tightness of weave, as affected by warp and filling yarn sizes and thread count, also has an effect on the laminate properties, particularly from the standpoint of resin impregnation. It is the combination of yarn and fabric structure that influences the properties of the final laminated product. The type of weave must also be taken into consideration in view of its effect on yarn crimp, porosity, and surface characteristics.

Types of weave

There are many different types of weave available to the laminator. Standard cotton industrial fabrics range from lightweight, high-count, staple lawns to a considerable variety of firm, heavy ducks. Each, of course, possesses its own special advantages which direct it toward specific applications.

SISAL FIBERS*

In the past few years, sisal fiber has become increasingly important in mat form as a reinforcement for plastics laminates and in chopped form as a filler for thermoset molding compounds, especially premixes. It is a low-cost material that for many purposes yields finished pieces with adequate impact and flexural strength, weatherability, and low moisture absorption.

Chemically a lignocellulose fiber, sisal is produced from the leaves of a tropical shrub belonging to the Agave group and is available in strands from 2 to 5 ft. long and 0.005 to 0.020 in. in diameter. Grading is on the basis of fiber length, whiteness, and degree of cleaning.

Laminates: Sisal mats are used in reinforced plastics with polyester or phenolic resins, the mats being available in weights of ½ to ¾ oz./sq. ft. in parallel strands and from 2 to 9 oz./sq. ft. in needled mats. Molding is usually in matched-metal shear type molds at a minimum pressure, with polyester resins, of 200 p.s.i. Loading can be in conventional filler-resin ratio with either calcium carbonate or calcium silicate.

Typical applications are in trays, tote boxes, waste baskets, and clothes hamper panels.

Sisal mats are readily impregnated with low-pressure phenolic resins and are moldable into relatively simple shapes of modest draw. Usually used in a ratio of 60% sisal and 40% B-stage resin, the proportion can be varied to as little as 30% sisal, with 30% filler and 40% resin.

Premix compounds: Chopped sisal fibers in lengths from ¼ to ½ in. are being used in low-cost premix compression molding compounds. Percentage of fiber in such premixes runs from 5 to 15%, depending on the application. These premixes range in specific gravity from 1.8 to 2.85, with impact strengths (Izod) of 1.1 to 2.3 lb./in. of notch. Flexural strengths of 6000 to 7000 p.s.i. are reported, and flexural modulus of 7×10^5 to 1.1×10^6.

When molding polyester-sisal premixes, temperatures of 300 to 350° F. and pressures of 450 to 1000 p.s.i. are used; over-all molding cycles of 1 min. are attainable on sections as thick as 0.250 inch.

Present volume applications of sisal-resin premixes are in gear housings, heater and air conditioning fan housings, window-type air conditioner bulkheads, and in many industrial applications of the nonelectrical variety.

It is estimated that 4 million lb. of sisal were used in premixes during 1958, with volume continuing to increase.

References

Consult the Subject Index for additional information on synthetic and cellulosic fiber reinforcements for laminates. See also the Laminates Chart. For sources of reinforcements, see Directory Index, p. 1078.

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*Based on information furnished by Standard-Union Fibre Co., 2950 E. Tioga St., Philadelphia 34, Pa., and Product Techniques, Inc., Hudson, Ohio.

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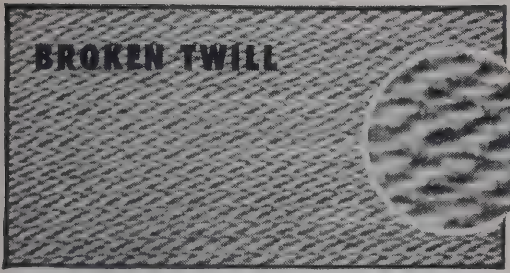

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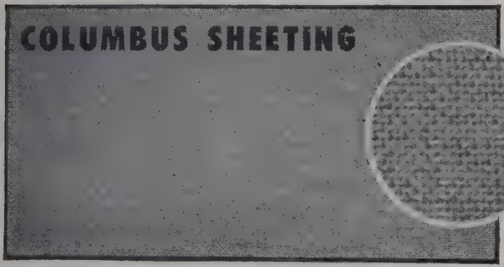

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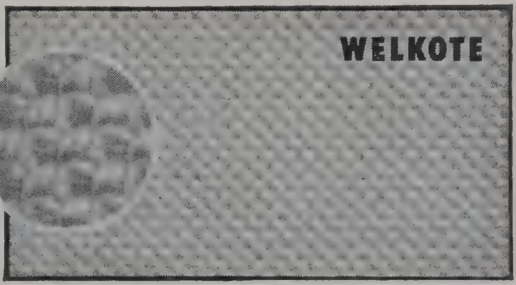

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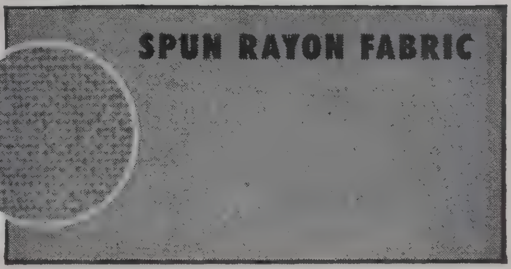

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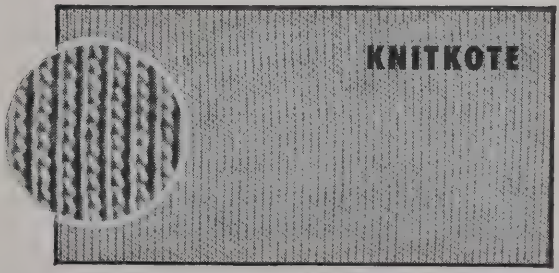

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APPLICATIONS FOR SANDWICH CONSTRUCTIONS

In aircraft and missile design, where weight control is vital, the structural rigidity of honeycomb sandwich construction has found wide acceptance. In addition, the aerodynamically smooth surfaces of a honeycomb panel in an airfoil shape provide the highly desirable characteristics of low drag and high performance. Ailerons, wing, fins, trailing edges, flooring, stabilizers, control surfaces, elevators, wing tips, and wing fillets are some of the honeycomb applications in aircraft construction. Lightweight rigid honeycomb structures are highly resistant to the tremendous vibration pressures encountered by supersonic aircraft. This type of acoustical bombardment quickly destroys ordinary structural materials.

It is, however, in the field of architecture that sandwiches will enjoy their largest use. A number of companies have begun to produce all-plastic panels with glass fiber-reinforced polyester skins, which have unusual possibilities as an integrally finished wearing surface. Two manufacturers presently feature translucent structural panels, an idea which might radically transform architectural design. Several other types available which point toward trends for the future are listed below:

1) Reinforced plastics facing with a foamed styrene core. This lightweight panel is often reinforced by incorporating a sheet of hard material (e.g., cement-asbestos board, plywood or hardboard) behind the plastics facing.

2) Metal facing with foamed-in-place polyurethane core.

3) Reinforced concrete faces with foamed styrene cores. Large panels of this type, which may be precast to full wall height and range in lengths from 10 to 20 ft., are most often employed in industrial buildings. The facings usually consist of 1½- to 2-in. thick concrete bonded to a foamed styrene core.

4) Reinforced plastics facing with aluminum grid core. This sandwich was used for the roof of the United States Pavilion at the Brussels International Fair. The reinforced plastics facings consist of glass fiber mats with a cover sheet and polyester resin binder. The facings are bonded to an aluminum extrusion core with a synthetic rubber-vinyl type adhesive. Different percentages of fillers in the facings are employed to control light transmission.

For a full discussion of plastics' involvement in the fast-growing field of sandwich constructions, readers are referred to the article on p. 204 which covers the subject of skins for sandwiches and to the article on p. 499 which treats with the various types of plastics cores going into the field.

Condensed from sections appearing in "Building With Plastic Structural Sandwich Panels," a study prepared by Mass. Inst. of Tech., Dept. of Architecture, in assoc. with the Plastics Div., Monsanto Chemical Co.

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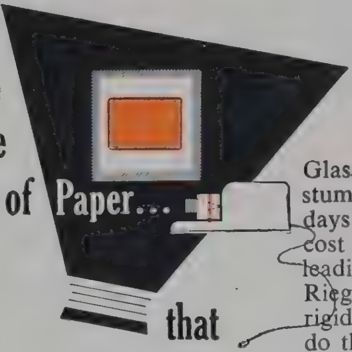

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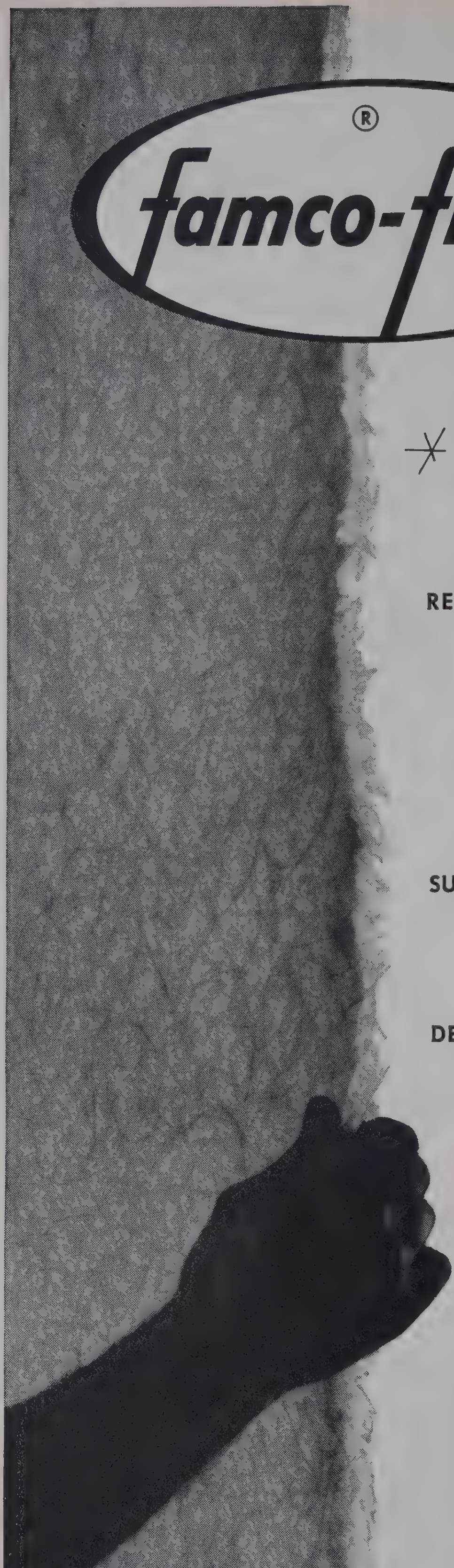

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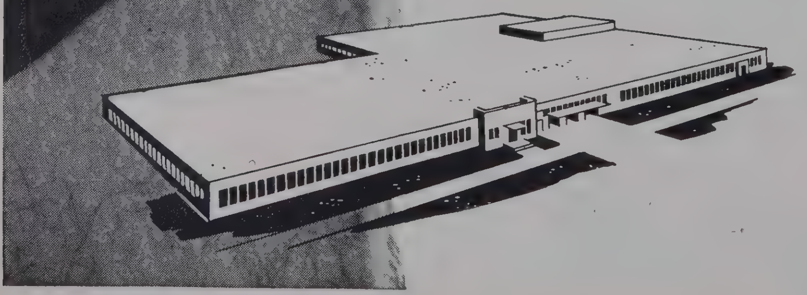

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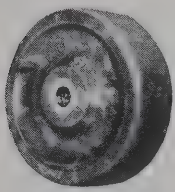

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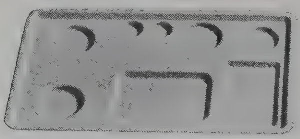

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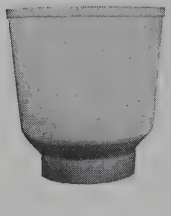

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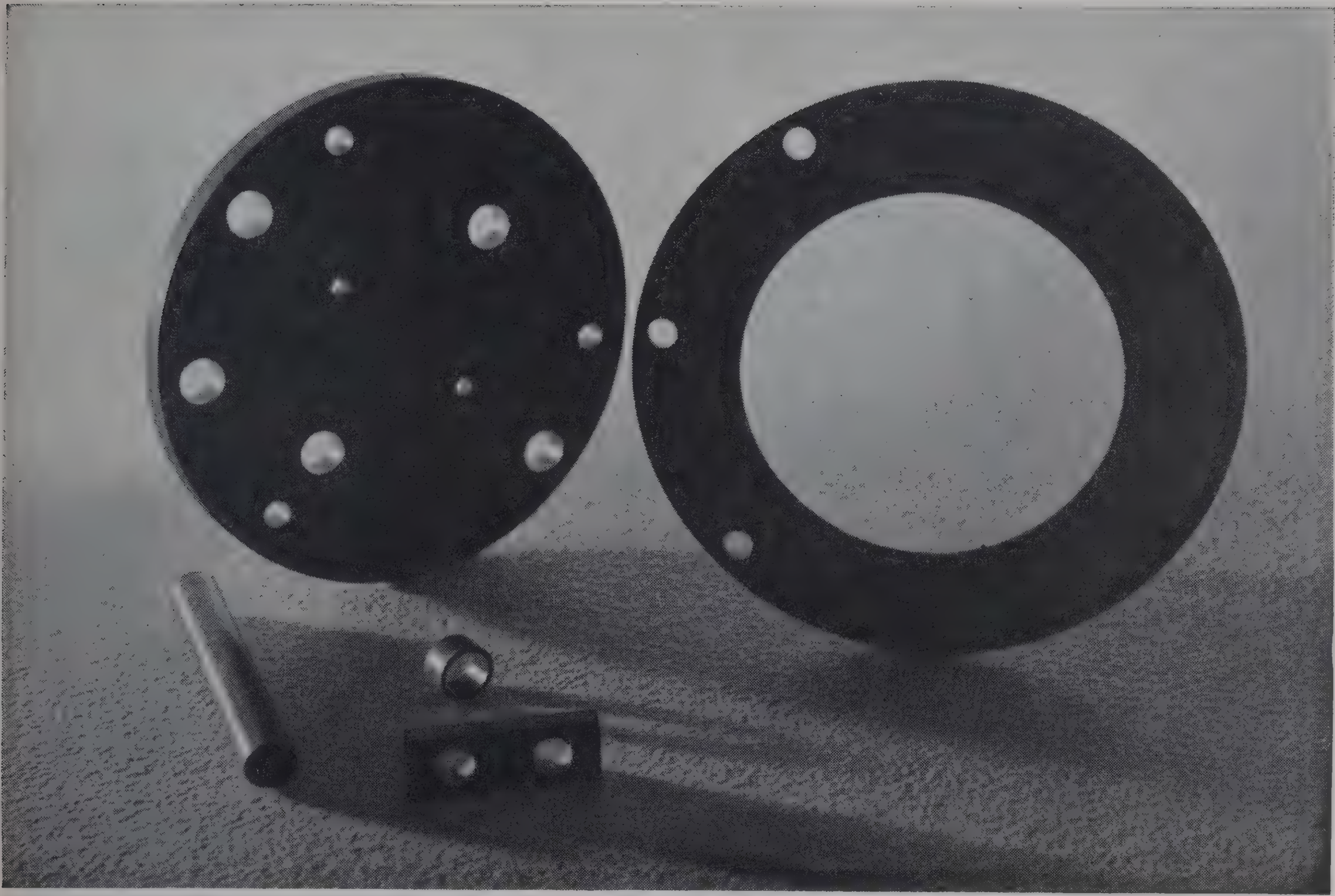

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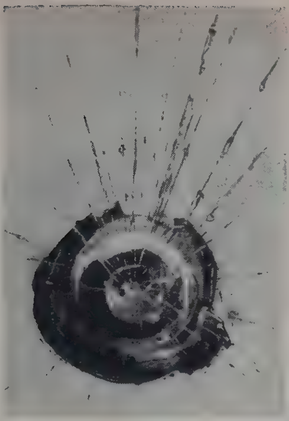

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LAMINATES AND REINFORCED PLASTICS

Laminates and laminating

By F. W. Jahns, Jr.*

In the plastics industry, "laminates" is a term used to cover the ground from vinyl sheets bonded together with decorative filler between to reinforced plastics moldings.

Loosely, a plastics laminate can consist of two or more sheets or films of plastics bonded together either with or without a substrate in between, or it can "consist of superimposed layers of a synthetic resin-impregnated or -coated filler which have been bonded together, usually by means of heat and pressure, to form a single piece."

The expression "laminates" as used in this article will refer to the latter definition. Here, too, however, a breakdown between "high-pressure laminates" and "low-pressure laminates" should be noted.

Basically, all thermosetting laminates are made by applying heat and pressure to filler materials that have been impregnated with a thermosetting resin. The heat and pressure thus applied serves to fuse the material into a dense, solid mass in the form of sheets, tubes, rods, or molded shapes.

In the past, the pressure required for manufacturing laminates has been used as a dividing line. The "high-pressure laminates" (which will be discussed in this article) are those requiring curing pressures over 1000 p.s.i. Further subdivision of this group is made on the basis of filler, resin type, or end-use (e.g., phenolic-glass, silicone laminate, or the decorative laminates, etc.).

The "low-pressure laminates" originally referred to those laminated materials, e.g., plywood and other nonplastics, made by molding or similar methods that did not require pressures over 400 p.s.i. With the appearance of filler-resin combinations, such as the fibrous glass-polyesters, that could also be molded at pressures under 400 p.s.i., the concept of "low-pressure laminates" was expanded to take in these materials. To add to the confusion, the term "reinforced plastics" has also come into use to describe these same materials, e.g., the glass-polyesters.

Today, the terminology in this area might be summed up in this way: "reinforced plastics" is virtually synonymous with "low-pressure laminates." A few years back, when one spoke of "reinforced plastics," chances are he was talking about polyester-glass combinations. Today, with all the activity going on with new resins, such as epoxies, and new reinforcements (asbestos, synthetic fibers, etc.), the description can be applied to any fiber-reinforced resin. Although the "low-pressure" terminology is still used, it should be remembered that for some purposes, techniques involving higher and higher pressures are being used to mold "reinforced plastics." Some are already close to the pressures used for the "high-pressure laminates." A further discussion on this will be found in the article "Molding Reinforced Plastics," which begins on p. 481.

One other departure from this accepted terminology should also be mentioned. Vulcanized fibre, although it has only one component, cellulose, may be considered a laminated plastic. It is made up of a number of layers or "laminations" of cotton cellulose paper. See p. 480.

Resins for laminates

Probably the most widely used resins in the high-pressure laminating field are the *phenolics*. These resins are low in cost, have good mechanical and electrical properties, possess good heat and flame resistance, resist normal moisture conditions, and are unaffected by mild acids and alkalies. Most paper- and cloth-reinforced laminates are of the phenolic type.

Melamines, because of their excellent color range, their good color retention, and their abrasion resistance, are used extensively in decorative laminate manufacture. The resin has, in addition, good resistance to flame, alkalies, arcing, and tracking, and consequently is also used for many industrial laminates (primarily in electrical applications). Melamines are more costly than phenolics.

Epoxy resins, also relatively costly, are used with fibrous glass cloth to provide a high degree of resistance to acids, alkalies, and solvents, as well as extremely low moisture absorption. Other properties of epoxy laminates: good dimensional stability, high mechanical strength, minimum gassing, high fungus resistance, superior bond strength, and com-

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* Technical Sales Service, Continental-Diamond Fibre Corp., Subs., The Budd Co., Newark, Del.

Recent Developments and References were prepared by the editors.

A new XXXP grade laminate (*Dilecto XXXP-31EFR,* Continental-Diamond Fibre Corp.) is designed for electrical applications where humid conditions are encountered . . . available in plain sheets in natural color, semigloss finish, or copper-clad (*Di-Clad 31 EFR*) . . . rapidly self extinguishing . . . absorbed only 0.35% water after a 24-hr. immersion test.

High impact strength and excellent electricals are offered in a new shock-resistant laminate (*Nelco 230-R* glass-reinforced XXP phenolic laminate, New England Laminates Co.) certified to equal or exceed requirements of MIL-P-3115-B, Type PBE-P grade . . . is furnished plain or copper clad . . . can be cold-punched in thicknesses up to 3/32 inches. An open-mesh glass fabric laminated into the material gives it flatwise flexural strengths of over 18,450 p.s.i. crosswise and 14,500 p.s.i. lengthwise in thicknesses of 1/16 inch . . . impact strength is 8 times standard NEMA requirement.

New copper finish that assures uniform coverage by all types of acid resist inks without further surface preparation has been developed (by Taylor Fibre Co.) for copper-clad laminated plastics. The finish also permits good solder buildup and coverage, making soldering easier and soldered connections more secure . . . improves printability.

Flame-resistant paper-based phenolic laminate (*Phenolite Grade XXXP-475,* National Vulcanized Fibre Co.) offers excellent electrical properties, very high insulation resistance, and low moisture absorption . . . for printed circuit applications . . . yields excellent punching results with a minimum of heating in the range of 130 to 150° F.

A high-heat-resistant plastic-and-fiber electrical grade material (*Duroid,* Rogers Corp.) is used in the Jupiter IRBM for antenna inserts . . . performance is not significantly affected by exposure to extreme temperatures encountered when the nose cone re-enters the atmosphere.

A new paper-base plastic laminate (*Grade FR-1,* Synthane Corp.) has good mechanical properties, high dielectric strength, and resistance to moisture, which makes it well suited for many electrical applications. It is also flame-retardant. Another laminate (*Grade EP-22*), an alpha-paper filler impregnated with epoxy resin, has excellent electrical characteristics over a wide range of humidities and temperatures and is especially designed for printed circuit and numerous other electrical requirements.

A flame-resistant grade of vulcanized fibre (National Vulcanized Fibre Co.) does not support combustion when subjected to A.S.T.M. and Underwriters' Laboratory flame tests . . . flame resistance results from an additive that completely penetrates the material . . . does not have the good electrical properties associated with standard vulcanized fibre.

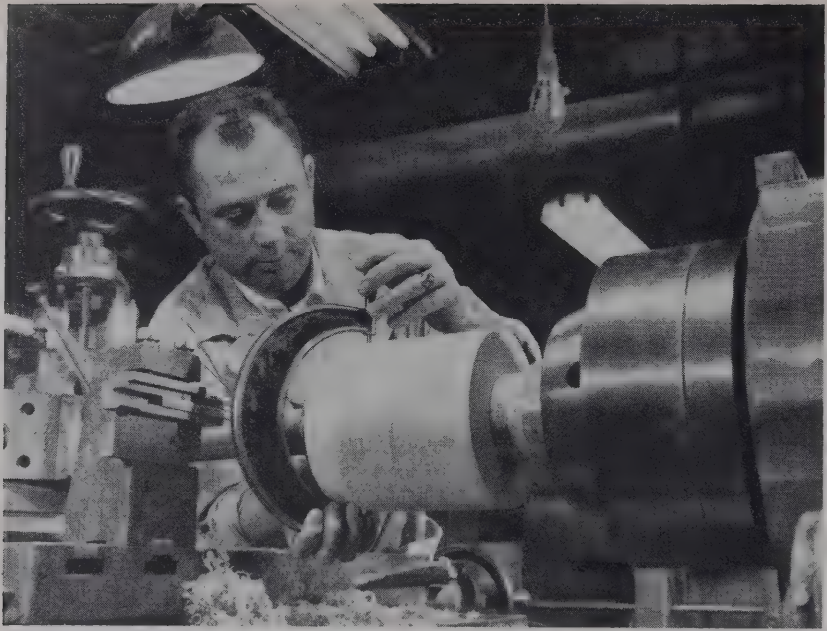
Rolled laminated-plastic tubes (Taylor Fibre Co.) are available with inside diameters as low as 0.050 inch. The small I.D. tubing was developed to meet the requirements of many applications, particularly miniaturization in the electrical and electronics fields . . . are furnished in Grade XX laminated plastic.

A new grade of decorative plastic laminate (*Universal Grade Micarta,* Westinghouse Electric Corp.), 0.050-in. thick, replaces the postforming and non-postforming grades formerly available . . . can be handled on all available types of postforming equipment. Cabinet doors, sink tops, desk tops, and vanities can now be postformed at a reduction in cost.

A new punching grade, phenolic laminate (*No. 4012-42 Lamicoid,* Mica Insulator Div., Minnesota Mining & Mfg. Co.) combines excellent electrical properties with impact and flexural strength more than 50% greater than that of regular NEMA grade XXXp laminates.

A highly purified form of lignin (*Indulin,* West Virginia Pulp and Paper Co., Poly-Chemicals Div.) is recommended as a phenolic resin extender for decorative laminates. . . produces laminates with better machining qualities, resulting in longer cutting tool life . . .varnish bleed through to overlay and consequent staining is eliminated or substantially reduced . . . costs are appreciably cut as the resins may be extended by 1/3 or more.

Excellent fire and arc resistance under damp or even wet conditions claimed for a new glass-melamine laminate (Formica Corp.). . . claimed to retain 70% of its dielectric strength after 336 hr. immersion in water at 50° C. and 50% after exposure for 1000 hr. under the same conditions . . . compares with 90% loss in 48 hr. common to other laminates sold under NEMA G-5.



LARGE-DIAMETER glass-melamine laminate tubing, here being turned on a conventional lathe, will find use in industrial and electrical applications of a demanding nature. (Photo, Continental-Diamond Fibre)

patibility with epoxy potting compounds used for encapsulation.

Silicone resins are also used, primarily with fibrous glass cloth, to provide a high degree of temperature resistance and superior electrical properties. They can resist heat up to about 500° F., and they have higher arc resistance and lower moisture absorption than phenolic laminates. They are also higher in cost than the phenolic laminates.

Polyester resins are used primarily in low-pressure laminate applications. They are also used to some extent in the high-pressure laminate field where they provide relatively good mechanical and electrical properties.

Another family of resins now being used with fibrous glass for high-pressure laminates are the fluorocarbons (e.g., TFE and TFCE). These laminates have outstanding heat resistance and are able to retain their low-loss electrical properties over a broad frequency range. In addition, they have an extremely low coefficient of friction and good resistance to chemical attack.

A wide range of base materials can be used with the resins described above to turn out specific laminates with desired characteristics and properties. These materials range from papers of many grades to various synthetic and natural fibers, as well as asbestos and other special materials.

Laminates based on *paper* reinforcement are generally used for electrical applications rather than in products for which mechanical properties are important. *Kraft* paper (from wood pulp) offers good mechanical strength plus low cost; *alpha-cellulose* paper (purified wood pulp paper) provides better electrical properties and improved machinability; and *rag* paper (from pure cotton fibers) gives improved strength plus lower moisture absorption.

Mechanical grades of plastics laminates, as opposed to electrical grades, use woven or nonwoven *cotton* fabrics as the base material.

Asbestos, nylon, glass, and some of the other *synthetic fibers* are used when greater heat resistance, high insulation resistance and high dielectric strength are required.

Of course, with all these fibers, various types of weaves and fiber lengths can be utilized to create special properties in the finished laminate.

Laminate manufacture

Saturation: Prior to the actual impregnating or saturation of the base material with the resin, it is often necessary to follow strict rules of storage when handling both the resin and the filler material. The resins, of course, must first be dissolved in a solvent to form the impregnation sirup. Generally, the resin solutions are prepared in fresh batches for immediate use to eliminate any possibility of solvent evaporation. When they are stored, however, they should be kept in air-tight drums, preferably in constant-temperature or air-conditioned rooms.

Certain grades of papers should also be stored under controlled conditions of moisture and temperature.

The initial step in the manufacture of a high-pressure laminate is passing the untreated reinforcing material through a trough containing the impregnating resin solution. The web of material is fed from rolls into the trough over guide rollers, and squeeze rolls or doctor blades are used to remove excess solution and to control the amount of resin remaining in and on the web. The degree of resin penetration will depend on such factors as the viscosity of the resin, the temperatures used, the permeability or absorption of the filler material, time of immersion, etc.

After leaving the saturation bath, the impregnated web passes through the drying chamber or oven, where, by means of controlled gas or steam heat, the desired degree of "dryness" is imparted by driving off the alcohol and other volatiles. The amount of resin left in the filler material can thus be controlled to anywhere from 20 to 80 percent. Volatiles may be collected and recycled or condensed for re-use in the batching operation.

Quality control of the degree of dryness is exceptionally important, since in fillers that are too "dry" the resins will not flow when the sheets are placed in the laminating press. The proper amount of impregnation is also important and many manufacturers maintain quality controls by sampling the impregnated materials as it emerges from the "dry" end of the coating machine.

Laminate sheets: Upon removal from the coating and drying machine, the webs are cut to the proper sheet size by rotary cutters

TABLE I: Properties and applications of industrial NEMA grade laminates[1]

NEMA grade	*Typical properties*	*Typical applications*
X	Paper phenolic. General-purpose grade, high strength, low cost.	Panels, contactors, terminal blocks, insulating washers.
P	Paper phenolic. Punch grade, not as strong as X. Low cost.	Spacers, switch links, and miscellaneous small punched parts.
PC	Paper phenolic. Similar to P but recommended for punching at ambient temperatures. Lower strength and greater cold flow than P.	Same applications as P except for limitation of strength and cold flow.
XX	Paper phenolic with better electrical properties than X or P.	Miscellaneous parts for communication equipment, switchboard panels, and exposed parts.
XXP	Paper phenolic better than XX in electrical properties and humidity resistance. Can be punched hot. High strength.	Relays, vibrators, tube sockets, communication equipment.
XXX	Paper phenolic. Suitable for high-frequency, low-loss application in high humidity.	Radio, radar, and television, high-voltage parts. Printed circuits.
XXXP	Best paper phenolic electrical grade. Highest dielectric strength and lowest dissipation factor. Can be punched hot (some manufacturers now offer a special XXXP grade that can be punched cold).	Punched parts for critical electrical application. High-voltage and high-frequency uses. Printed circuits.
ES-1	Paper base engraving stock. Core and face of contrasting color.	For engraved nameplates.
ES-2	Similar to ES-1 except for color.	For engraved nameplates.
ES-3	Similar to ES-1 except for color.	For engraved nameplates.
C	Cotton fabric phenolic. Cloth heavier than 4 oz./sq. yd. Not recommended for electrical uses. High impact strength.	Mechanical application gears and bearings, rayon spinning buckets, miscellaneous disks, pistons, and rings for pumps and valves.
CE	Similar to C but with controlled electrical properties. Better in humidity; not for high-voltage primary insulation. Better for machining than grade C.	Bus bars, panel boards, slot wedges. Many applications same as C.
L	Cotton phenolic with fabric less than 4 oz./sq. yd. Called linen grade by the trade. Better machining than C and CE. Lower impact strength than C. Not an electrical grade.	Mechanical parts for pumps, valves, clutches, etc. Small gears and bearings.
LE	Similar to L but with better moisture resistance and controlled electrical properties. Not as good electrically as paper-base laminates. Not for high-voltage primary insulation.	Small parts, both mechanical and electrical, that require good punching and machining qualities.
MC	Melamine laminate reinforced with cloth similar to C grade. Excellent arc resistance and better resistance to alkali than phenolic laminates. Between C and CE in moisture absorption.	Electrical uses requiring arc resistance. High-voltage switchgear and terminals.
A	Asbestos paper phenolic. Better heat and flame resistance than cellulose paper phenolic. Not recommended for primary insulation at over 250 v. Difficult to machine. Very low moisture absorption. Very low cold flow.	Low-voltage, electrical application in electric welders, traction motors, etc.
AA	Asbestos cloth phenolic. Properties similar to A but better strength.	Often molded into shapes for collector rings, commutator parts, and armature wedges.
G-2	Staple fibrous glass cloth, phenolic binder. Excellent electrical properties under high humidity. Very low dielectric losses.	Electronic equipment.
G-3	Continuous filament glass cloth-phenolic laminate. High strength except bond strength is poor. Good dimensional stability at elevated temperatures.	Electronic equipment.
G-5	Continuous filament glass cloth-melamine laminate. Second only to silicone laminates in arc and heat resistance. Best in flame resistance.	Electronic equipment. Printed circuits for high voltage.
G-6	Stable fibrous glass cloth with silicone resin binder. Superior dielectric loss and insulation resistance properties. Good heat and arc resistance. Meets AIEE requirements for Class H insulation.	Electronic application requiring Class H material or very low dielectric loss.
G-7	Continuous filament glass cloth with silicone binder. Similar to G-6 except flexural strength is higher and bonding strength is lower.	Similar to G-6.
G-10	Continuous filament glass cloth with epoxy resin binder. Extremely high flexural impact and bonding strength. Superior electrical qualities in humidity.	High-frequency electronic parts. Printed circuits for military applications.
N-1	Nylon cloth base with phenolic binder. Excellent electrical properties in high humidity. Good impact strength, low modulus. Easy to punch. Subject to flow at elevated temperatures.	Specified by MIL-P-15047 for certain military applications.
CF	Cloth phenolic similar to C grade except that it can be formed into simple shapes when heated. Called postforming grade.	Used to form angles, channels, and other simple shapes. Not recommended for high-voltage electrical applications.
GPO-1	Random fibrous glass mat bonded with polyester resin. A low-pressure laminate. Can be made flame retardant. Good arc and heat resistance.	Mechanical and electrical uses. Excellent for structural applications requiring an insulating material.

To choose a laminate for particular application, reference should be made to the standards publication of the National Electrical Manufacturers Association, 155 E. 44 St., New York 17, N. Y., or to the catalogue information supplied by one of its members. In most cases, catalogue information is to be preferred because manufacturers often have more than one grade corresponding to a given NEMA classification.

[1] Prepared by Laminated and Insulating Products Dept., General Electric Co.

or guillotine blades. The sheets are then sorted according to grade and thickness, and laid, according to the desired specifications in the end product, one on top of the other in "sandwich" form. By weighing the lay-up, the laminator can decide when the predetermined weight that will give him a desired thickness in the finished laminate has been reached.

By varying the type of sheet used in the lay-up, a wide range of properties can be built into the laminate. A vulcanized fibre facing can be used with a phenolic core, for example, to impart arc resistance, or an epoxy-glass facing can be used to provide high mechanical strength. Sheet copper can be used as a facing when the laminate is intended for use in printed circuitry.

The "sandwich" is then placed between stainless steel sheets of about the same size as the desired laminate sheet and the entire lay-up is placed between the heated platens of a vertical-acting, multi-opening platen press. The press is then closed, and heat and pressure are applied. If sheets are desired that are longer in size than is possible to make in conventional presses, joining techniques known as "butt welding" or "overlaying" can be utilized.

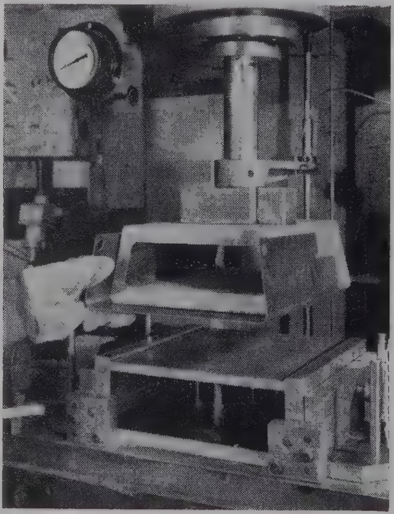
The platen presses used are heated by steam, by hot water under pressure, or by electricity. The electrically heated presses are usually confined to silicone laminates, for which they can provide precisely controlled curing temperatures. Temperatures and pressures average about 300 to 350° F. at 1000 to 1200 p.s.i., and cycles may run from ½ hr. up to 4 to 8 hr.—depending on thickness and number of sheets, type of resin and base material, and other factors.

After fusion has taken place in the press, the laminate must be cooled slowly by a gradual reduction of heat and pressure to ambient and atmospheric values, or else embrittlement of the surface layers may occur. In certain circumstances, the laminate can also be removed when a predetermined temperature has been reached, and placed in a curing oven at the same temperature. This, of course, leaves the press free for the next operation.

Rolled rods and tubes: In another type of operation, as the impregnated web is taken from the coater-dryer, it is cut to desired length and rolled convolutely on a polished stainless steel or chrome-plated mandrel. The mandrel, with the impregnated sheet wound around it, is placed between heated rollers and a pressure roll. For certain resins and filler materials, it is sometimes necessary to heat the mandrel beforehand to insure adequate resin flow between layers. As with the sheets, the tube assembly is cured in an oven to complete the fusion. The mandrel is then withdrawn and the tube is centerless ground or otherwise machined to the desired dimensions. Rods can also be made using the same technique, except that the mandrel is much smaller in diameter and is withdrawn *before* heat and pressure are applied.

Molded rods and tubes: It is also possible to produce laminate rods and tubes by molding them in heated, split-type molds of either rectangular or circular cross-section. Again, however, it is a combination of impregnated sheets convolutely wound around a mandrel that is placed in the mold. In molding rods, as opposed to tubes, the mandrel is again removed before placing the wound preform into the mold. Square or rectangular tubes are later sliced into a variety of smaller parts or they may be used full-length for such applications as conduits, bus-bar insulation, etc.

POSTFORMING-grade laminates can be bent to shape by heating the material in an oven or by infra-red and then forming in a low-cost cold mold.



Molded laminates: Molded laminates are of particular interest to the design engineer, since they afford him an opportunity to make use of many intricate or unusual shapes. Either cut-to-shape impregnated materials or chopped-up (macerated) impregnated materials are placed in a mold of the required design and cured by applying heat and pressure. By proper saturation, use of preforming techniques, and correct positioning of the material in the mold, the final product can be given greater strength and more accurate contours than would be possible by fabricating the part from sheet stock. Molded-macerated laminates are particularly adaptable to intricate shapes or to parts requiring great mechanical strength and wear properties, e.g., casters, truck wheels, pulleys, valve parts, gears, etc.

Combination laminates

As requirements have become more specialized, the trend in the "high-pressure laminates" field has been towards the use of plastics laminates in combination with other materials, e.g., steel, aluminum, copper, rubber, cork, etc., to achieve distinctive properties in a single material. The strength-weight ratios, for example, can be improved, resistance to abrasion, corrosion, and impact can be increased, a greater range of electrical characteristics are possible, and so on.

For many years, metal tubes have been covered with phenolic laminates for use as conveyor rolls in metal-processing operations. It is also possible to use conductive inserts, such as aluminum or copper foils, in the make-up of paper-base or other types of laminates. The conductive inserts provide a means of ground connection and also increase the corona resistance due to improved distribution of the electrical stress.

Combinations of laminates with cork or rubber serve to seal the tops of electrolytic condensers more effectively than either material alone. Retainers for precision ball bearings, made from a combination of a plastics laminate with aluminum, provide great accuracy and permit reduction of the bearing size. Printed circuits use a plastics laminate in combination with copper to give structural strength and punching characteristics to the copper while providing high dielectric strength and arc resistance. Aluminum tubes with phenolic-fabric laminates are used in aircraft landing gear equipment and hydraulic pistons. The combinations thus possible are endless.

Applications

Because the laminates can thus be designed to offer any specific combination of a wide range of properties, their use as a valuable industrial and engineering material is increasing. Innumerable combinations of electrical, physical, and mechanical properties are available—and not only in the special laminates described above but in the standard laminates as well (see Table I: Properties and applications of industrial NEMA grade laminates, p. 471).

The high strength-weight ratio of plastics laminates, their great tensile strength, flexural strength, and rigidity make them ideal for many structural, aircraft, and other important industrial applications. In addition, they are easily machined and unaffected by steam, oil, and most corrosive atmospheres. They are exceptionally wear-resistant and will not delaminate under normal conditions. Gears machined from laminates take advantage of many of these outstanding properties and today are one of the larger markets for the industrial laminate materials.

The excellent dielectric properties of the laminates have opened up a good number of applications in the electrical field. For one thing, they can allow reductions in the size of electrical insulating parts that must also withstand high mechanical stresses. Epoxy laminates, with their excellent dimensional stability, low water absorption, minimum gassing, and high mechanical strength, are becoming increasingly important in the electrical market.

Printed circuits based on laminate materials are being widely applied in industrial electronic equipment, home appliances (radio, TV sets, hi-fi amplifiers, etc.), and military applications, particularly in the control circuits for guided missiles.

During the past year, paper-base epoxy laminates have been widely used for printed circuit applications because they offer the advantages of lighter weight, easier fabrication, and lower cost than glass-base laminates. They also feature better flame retardancy and lower moisture absorption than paper-base phenolic laminates.

In addition to printed circuits, guided missile applications of laminates include fins and guidance systems. It should be noted that although these guidance systems constitute only 5 to 10% of the total weight of the missile, they usually represent about 50% of the entire cost.

Compressor blades of jet aircraft engines are an example of uses being found for laminates impregnated with high-temperature-resistant laminating resins. Considerable work is also being done in this same area of increasing operating temperatures (over 2000° F.) with the theory of *ablation*—a technique whereby the hot side of the laminate is allowed to disintegrate under exposure to extremely high temperatures while the cold side remains sufficiently sound structurally to do the required job.

For bearing applications, the use of a fluorocarbon resin or the addition of graphite and molybdenum disulfide to laminates has reduced the coefficient of friction considerably.

References

Consult the Subject Index for additional information on laminates and laminating. See also the Laminates Chart and the Low-Pressure Laminating Resins Chart for information on properties and trade designations. For sources of laminates and laminating resins and equipment, see Directory Index, p. 1078.

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Machining laminates

By E. C. Graesser*

Laminated plastics material may be machined on standard machine shop equipment by shearing, slitting, sawing, milling, turning, drilling, threading, tapping, planing, shaping, and punching. In many cases, the same machining operations employed in the fabrication of soft brasses or aluminum may be adopted; however, certain slight changes in tools and speeds are necessary.

With laminated materials, the direction of the laminations determines the strength of the finished part and must be kept in mind when machining. Also, various grades of laminates differ in machining characteristics and a basic knowledge of the material's properties and characteristics is helpful.

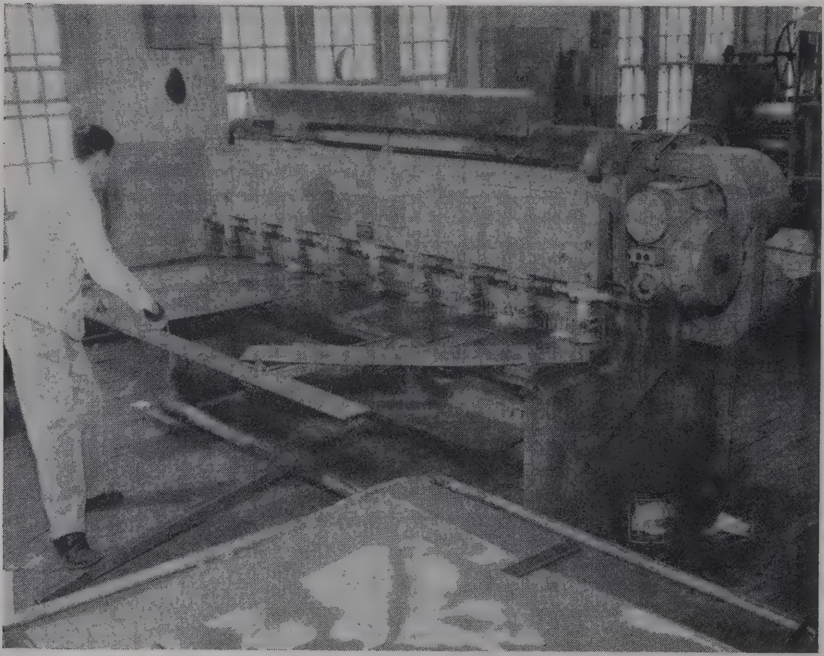
Standard tools are adequate for most fabricating operations; however, carbide tools will give better performance, particularly on production runs, and will have longer life between sharpenings. Diamond-tipped tools are recommended for exceptionally long runs and for abrasive laminates, e.g., those containing glass and asbestos.

It is of primary importance to keep tools sharp and operating at the proper speeds. Coolants can be used, but are not generally necessary. A good exhaust system should be used on all machining operations.

Shearing and sawing

Shearing of laminated sheets can be done successfully on metal squaring shears of the guillotine type. Paper base punching grades up to ¹⁄₁₆ in. in thickness and fabric base grades up to ⅛ in. can be sheared at room temperature. Grades other than punching grades can be sheared by heating to 200 to 280° F., depending upon thickness and grade. Shearing may be performed at speeds of 50 strokes per min. with hand feed. Rotary slitting machines can be used for gang slitting strips to close tolerance.

SHEARING of laminates can be done on metal squaring shears of the guillotine type at speeds up to 50 strokes per min. with hand feed



Sawing: Where close tolerances or smooth edges are not important, a standard metal or woodworking bandsaw can be used; contour sawing can best be done on a bandsaw. Bandsaw blades of file-hard carbon steel, hardened steel blades with soft backs, or diamond-edge-coated steel blades can be used. When cutting circles on radius, a blade 37 mils thick and ¼ to ½ in. in width, depending on radius, is recommended. For straight or block cutting, a blade 42 mils thick and from 1 to 1¼ in. wide should be used, depending on thickness of material. More set is required for sawing disks than for sawing strips or blocks. Cutting speed of up to 9000 surface ft./min. can be used. Work should be fed into blade as fast as it will cut without forcing the material.

When smooth edges and close tolerances are required, the circular saw should be used. Standard floor or bench circular sawing machines can be used for sawing dry up to 1 in. thick. The saw blade should be semi-high-speed or high-speed steel, hollow ground without set, having 150 teeth for a 12-in. diameter, or 126 teeth for a 10-in. diameter blade. The thickness of the blade will vary, depending on thickness and grade of material to be sawed. On thicknesses up to ¼ in., a ¹⁄₁₆-in. saw should be used; on thicknesses from ¼ to ½ in., a ³⁄₃₂-in. thick blade, and a ⅛-in. blade for thicknesses up to 1 inch. The saw tooth should be square, sharp, and free from burrs. The cutting tooth angle can be determined as follows: a straight-edge placed on the side of the saw in line with the cutting face of the tooth should pass directly through or up to 5° back of the arbor hole.

For each thickness and grade of stock, there is an elevation of the saw above the table that will reduce chipping to a minimum. Set the saw so that it just protrudes through the work, then adjust upwards until the smoothest cut is obtained. Speeds from 2850 to 3600 r.p.m. should be used. The stock is fed by hand into the saw as fast as it will cut without forcing. Idling creates friction and heat, which causes excessive dulling and burning.

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* Chief engineer, Fabricated Parts Engineering and Quality Control, National Vulcanized Fibre Co., Wilmington 99, Delaware.

References were prepared by the editors.

Small tubing may be cut by feeding the material straight through the saw. Saws 1/16 in. thick with 8 teeth per in. should be used. Heavy wall tubing should be rolled through the saw to prevent excessive breakout.

Carbide-tipped saws, diamond-impregnated wheels with copper body 1/16 in. thick, and abrasive blades are advised on harder grades of stock and long runs.

Milling

All laminates can be milled on standard metal production milling machines with standard milling cutters.

Speeds are higher for milling laminates than for most metals. Climb milling is recommended to prevent the cutter from lifting the layers of material.

Cutter speeds of 1000 to 1500 surface ft./min. are possible. Feeds should be controlled to avoid excessive temperature rise. Carbide-tipped cutters should be used for high production. Cutters should be ground with a zero rake angle.

For the harder glass and asbestos grades, surface speeds of about 400 to 800 ft./min. are recommended.

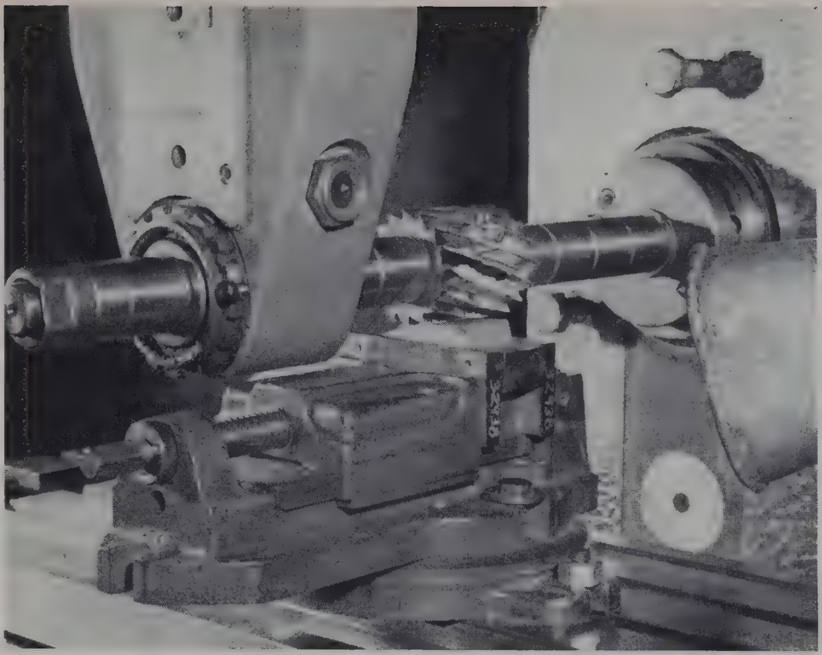
Milling is a relatively simple operation with laminates if normal care is taken that chips are removed and cutters kept sharp.

Gear cutting

Gears may be cut from laminated gear grades by milling, shaping, or hobbing on standard metal gear-cutting machines. The highest speed and feed of the machine should be used. It is good practice to cut gears in multiples and the last blank should be backed with some rigid material to prevent breaking out of the last few laminations.

Lathe and screw machining

Conventional turning, boring, facing, and threading can be done on automatic screw machines, turret lathes, and standard and production lathes. Clean, smooth, accurate surfaces can be obtained at high speeds.



MILLING of laminates can be successfully accomplished on standard metal production milling machines with milling cutters

Speeds and feeds should be much higher than those for machining brass or aluminum. High-speed steel, carbide-tipped, and diamond tools are used: high-speed tools for short runs, carbide-tipped for medium runs, and diamond tools for long runs. Turning and boring tools should be ground with a slightly round nose having 15° front and side clearances with zero-to-slightly-negative rake. Tools should generally be mounted at, or slightly below, the center line of the part and should be kept sharp at all times.

Automatic screw machines should be run at high speeds. Surface speeds up to 1500 ft./min. with 2- to 15-mil feeds can be used, depending on the rigidity of set-up, tolerances, and finish desired. Threading, in general, can be accomplished with self-opening dies.

Surface speeds up to 3000 ft./min. are recommended for standard and production lathes. Cutting feeds will vary, depending on finish and tolerances required. Threads can be readily cut on the lathe with a single point tool.

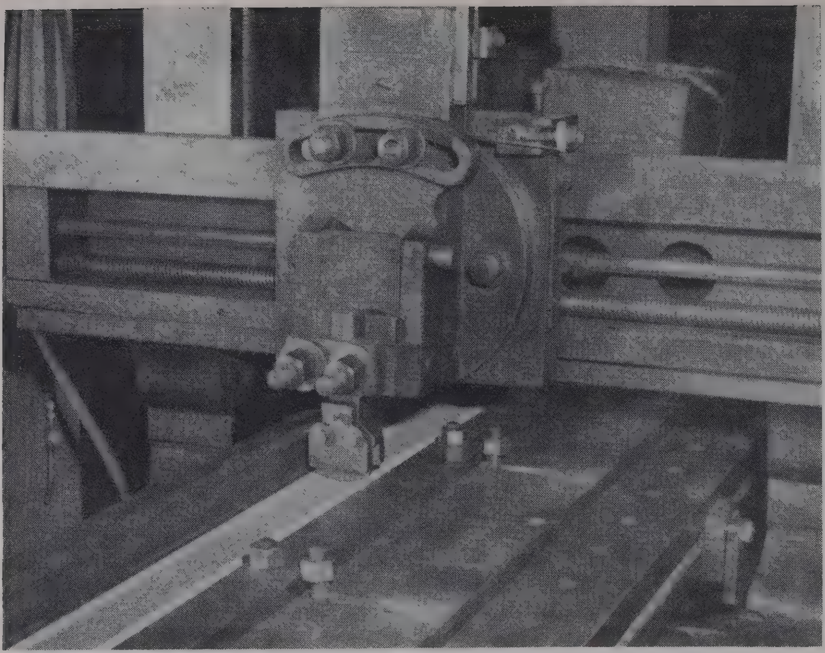
Turret lathes should be run at high speeds. In general, feeds and cutting speeds will be the same as those used for standard and production lathes.

Glass-base laminates should be machined with carbide-tipped tools at lower surface speeds than are employed for paper-base laminates.

Drilling

Standard drilling machines—bench, vertical, horizontal, single, gang, or multiple—can be used. Under normal conditions, laminates are easy to drill but there are some precautions to be observed. When drilling deep and blind holes, the drill should be withdrawn frequently to cool and to clear away chips. In drilling through holes, the feed should be reduced when approaching the break-through point to help minimize chipping on the lower surface. Where possible, the material should be backed up with a piece of rigid scrap material to give a clean, sharp hole. When drilling parallel to the laminations, the material should be clamped on both sides to help prevent splitting.

Drilling should be done at the highest speed possible without burning the drills. A 1/4-in. drill should be run at least 2500 r.p.m. and 10,000 r.p.m. would not be excessive for a No. 60 drill. The use of high-speed drills, high-



PLANING AND SHAPING of laminates is done on standard metalworking tools. Recommended speed, depending on grade, is 40 to 90 surface ft./minute with carbide-tipped tools

speed nitrided drills, and carbide drills are recommended.

Drills especially designed for use on laminates are now available. Standard drills can be used by grinding the point angle to 80 to 90° with a lip clearance of 15° and the cutting edge of the lip to zero rake.

It is advisable where tolerances are close to use a drill a few thousandths larger than the size hole wanted or otherwise holes will come undersize. This can also be accomplished by grinding the drill off center. It also will reduce friction and heat.

Drilling should be done with a light uniform pressure. Drills should not be forced, and, if sharpness is maintained, will require less pressure.

Tapping

The methods for tapping holes in laminates are much the same as for tapping brass and aluminum. Tapping can be done by hand, on standard drill presses with tapping heads or collapsible taps, or on special tapping machines. Standard high-speed-steel taps can be used but carbide taps should be used on any sizable runs. Taps should be purchased 2 to 5 mils oversize. A class 2 fit with 65 to 75% of thread can be obtained.

Taps should be ground with a negative rake of about —5° on the front face of the land; ample clearance is necessary to insure accurate cutting and to prevent binding and chipping when backing out.

When tapping parallel to the laminations the part should be clamped in the same way as for drilling to avoid splitting of the laminate and to insure uniformity of the threads.

Holes should be drilled to result in 65 to 75% of full thread. The entering side of hole to be tapped should be chamfered to prevent lifting of the surface.

Planing and shaping

Laminates can be planed and shaped on standard metal-working shapers and planers. Recommended speed, depending on grade, is 40 to 90 surface ft./min. with carbide-tipped tools. High-speed-steel tools can be used for short runs. Tools should be ground with up to 10° negative rake and side and face clearances from 10 to 30 degrees. When cutting across the laminations, the end of the cut should be backed up to prevent chipping.

Punching

Laminated materials are available in many different grades. Some punching grades can be punched cold in thicknesses up to $\frac{3}{32}$ inch. Harder grades require heating in thicknesses from $\frac{1}{32}$ in. up. The degree of heat used depends entirely upon the thickness and grade of the material. Often 200° F. is enough but in some cases up to 275° F. is required. Methods of heating employed include steam platens, electric platens, infra-red lamps, or ovens.

The various types of dies used are plain blanking, shaving, pro-

PUNCHING OF laminates can be accomplished on standard power-driven presses at the rate of approximately 350 strokes per minute

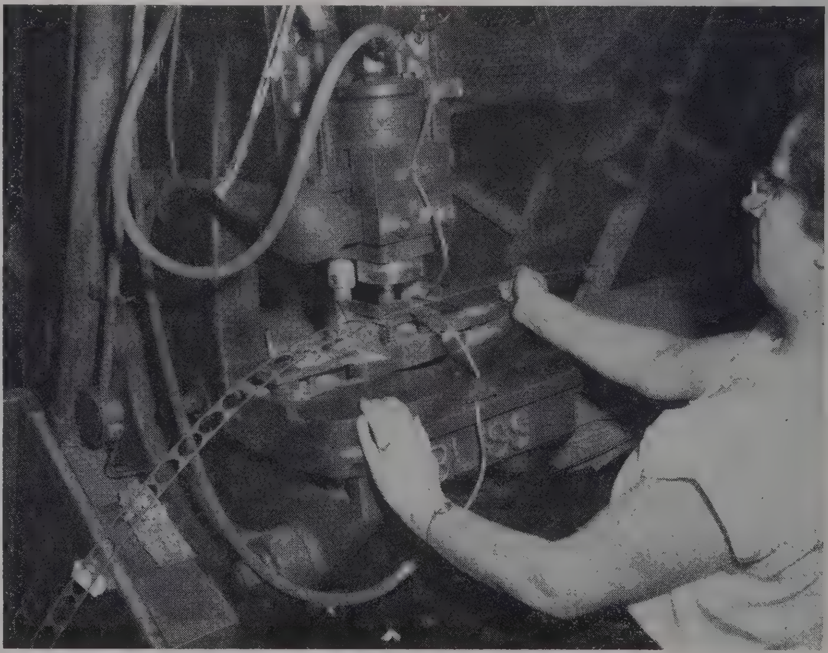


TABLE I: Approximate dimensional correction factors for plastics with paper or cotton fabric bases

	Blanking die size		*Piercing punch size*	
Material thickness	*Cold punched*	*Hot punched*	*Cold punched*	*Hot punched*
(in.)	*(in.)*	*(in.)*	*(in.)*	*(in.)*
1/32	—0.022	—0.0000	0.0020	0.003
1/16	—0.004	—0.0015	0.0040	0.007
3/32	—0.004	—0.0015	0.0065	0.010
1/8	—0.004	—0.0015	0.0090	0.012
3/16	—0.004	—0.0015	0.0150	0.016

gressive, compound, and combination dies. Standard power-driven presses are generally recommended. Punching may be done at speeds up to 350 strokes per minute.

In good punching practice the edges of the piece should not be closer to the edge of the strip than twice the thickness of the sheet. Holes should not be smaller in diameter than the thickness of the sheet and the distance between holes (or between holes and the edge of the piece) should not be less than the thickness of the sheet.

Punch and die dimensions are different than those for metal. All laminated plastics expand considerably when heated. When punching is done at elevated temperatures the blanks shrink as they cool to room temperature. This would seem to indicate that the blank would be smaller than the die. This is not true because all laminates will yield when they are punched.

Yielding causes the blank to increase in size by an amount greater than the amount of shrinkage during cooling. Thus, blanking dies for hot punching should be smaller by the amounts shown in Table I. In hot punching, for lateral dimensions over 1 in., effects of thermal expansion must be compensated for in the calculation of distances, center-to-center between punched holes and also the over-all length. In such cases a factor of approximately 2 mils/in. of length should be allowed (based on punching at approximately 225° F.). In the case of cold punching, the only effect is that of yielding and the die size is even smaller than that for hot punching because there is no thermal contraction.

Similarly, because of effects of shrinkage and yielding, piercing punches must be sized larger as shown in Table I, above. Varying with thickness in stock and method of punching (hot or cold), blanking dies are smaller and piercing punches are larger. The values given in Table I are sufficiently accurate to produce parts with tolerances of ±3 mils for paper- and cotton-base grades of laminates. To obtain best results, clearances between punches and dies should be kept to a minimum (1 mil max.) and the die kept sharp.

Reaming

Reaming of laminated plastics can be done with conventional reamers with a fast feed to produce holes with a good finish. Reamers of the expansion type with carbide inserts are recommended where close tolerances are required.

Marking

Laminates may be marked by means of engraving, stamping, or printing. Engraving can be done on standard pantograph machines with single lip, high-speed steel, or carbide-tipped cutters. Characters may be filled with colored lacquers to be read easier.

Stamping can be done in standard marking machines with or without roll leaf. Stamping can also be done in punch presses by including the characters in the die.

Printing can be done by the silk-screen method, rubber-stamp printing, and on standard printing presses.

Finishing

Laminated plastics can be surface-finished by grinding, sanding, tumbling, and buffing.

Grinding of tubes and rods can be done on standard centerless grinding machines of the type used for metals. It is suggested that the recommendations of grinding wheel manufacturers be followed for the type of grinding wheel to be used. In grinding it is advisable to keep work and wheel flooded with a coolant, to wash away the grindings, and keep the wheels free.

Standard belt, disk, and drum sanding machines may be used either dry or wet. Belt and disk sanders are used to finish shaped surfaces, for roughening (preparatory to gluing), and for removing burrs and sharp edges. Abrasive belts and disks ranging from 40- to 240-grit, depending upon the finish required, may be used.

Sheet and strips can be sanded to close tolerances on a double-drum sander using abrasive papers as fine as 180- to 220-grit, which will provide smooth finishes.

Machined parts often require the removal of dust, burrs, and fuzz. Many methods can be used, including hand filing, emery cloth, emery wheels, steel wool in drill presses, tumbling barrels, and impact blasting.

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Preforming fibrous glass

By W. W. Thompson* and R. G. Adams*

Three basic methods have been developed for preforming fibrous glass: 1) plenum chamber; 2) directed fiber; and 3) water slurry.

Plenum chamber method

Perhaps the most widely used process is the plenum chamber method. Fibrous glass rovings are fed into a cutter where they are cut to lengths between ½ and 2 inches. The 2-in. length is most often used, although shorter cuts, or a combination of lengths, are also in common usage. From the cutter the fibers fall into the plenum chamber, or into a chute that carries them into the plenum chamber. Here they are deposited on a perforated preform screen as the air is exhausted from beneath the screen.

To help insure uniform deposition of strands, the preform screen rotates. In addition, internal baffles on the screen are frequently used to aid in the proper deposition of fibers. A resinous binder, which may be either a powder or a liquid, is applied at the same time the glass is being deposited. Liquid binders, usually polyester and water emulsions, have been found to be the most satisfactory for the majority of types of applications.

The cutter acts as a feed mechanism for the glass; thus glass input can be controlled by a timer. The input of the resinous binder can also be controlled by a timer, although manual spraying is occasionally used.

The plenum chamber machines are the most nearly automatic of the air-type preformers and give the highest rate of production. Their operation is somewhat cleaner since they are enclosed. A big advantage of the plenum chamber method is that once it has been set up to do a particular job, very little operator skill is required to get reproducible results throughout a production run.

The disadvantages center around the long setup or tryout time which may be required whenever a new part is started in production. This is due to the fact that the fiber deposition depends entirely upon the correct flow of air through each part of the screen. To achieve this, intricate baffle systems within the screen often have to be developed. This setup can take several days. The plenum chamber machine is therefore most adaptable for long runs.

Directed fiber method

In the directed fiber method there is no plenum chamber over the screen. The preform screen is located on a nearby vertical turntable behind which is located an exhaust fan. The cut fibers are directed at the preform screen from the flexible hose of a separate cutter unit. The cutter unit consists of a roving cutter, a blower provided with a venturi where the cut fibers are introduced, and a flexible hose.

The rovings are cut in the roving cutter, dropped through a short duct, and introduced into the air stream, which blows them out of the flexible hose. The operator directs the stream of fibers at the slowly rotating preform screen on the turntable. The binder is simultaneously sprayed onto the piece by the operator.

While the glass input is controlled by a timer, considerable operator skill is required to produce uniform preforms. He controls the distribution of both fibrous glass and binder on the screen, and therefore the quality of the part. Where relatively lightweight preforms are being made, a strong light behind the preform screen is of value.

One of the chief assets of the directed fiber method is that, given a skilled operator, a part can usually be put into production within a few hours after the preform screen is delivered. Baffling is seldom necessary in screens since the operator can direct the fiber stream to any part of the screen. In the same manner, the operator can allow for varying part thicknesses where the changes are not too abrupt. It is also quite easy for the operator to add inserts, mat build-ups, or wire beads to the preform. Even in instances when a wide variety of different parts is to be made and change-overs are frequent, the directed fiber method is still adaptable. Several different sizes and shapes of parts can be run one after another on the same machine. The only adjustment the operator has to make is to set the correct cutter time for the part.

This method has been shown to be adaptable to making very large parts, up to 120 sq. ft. in area, and over. The directed fiber method is also useful in preforming odd-shaped parts, such as a very long and narrow piece or large pieces with considerable open area in the center.

Although theoretically capable of the same rate of production as a single-station plenum chamber machine, a slightly lower rate is usually experienced with directed fiber machines.

Water slurry method

The water slurry method is very similar to methods used in the pulp molding industry. The chopped strands of fibrous glass are slurried in water containing cellulosic fibers. Both glass and cellulose fibers are deposited on the preform screen as it is raised from the slurry bath and the excess water sucked out. Various ratios of glass-to-cellulosic fibers can be used although 80% fibrous glass and 20% cellulose seem to produce good results.

This method is the only one in

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* Owens-Corning Fiberglas Corp., 598 Madison Ave., New York 22, N.Y.
References were prepared by the editors.

which there is little or no scrap loss. It is more automatic and fast production cycles are possible. The preforms are tough and self-supporting without the addition of resinous binders. Intricate shapes, abrupt changes in wall thickness, and very heavy wall thickness are all possible. The initial capital investment for equipment is higher than for the air systems because more equipment is involved.

Although water slurry preforms handle easier than air-felted preforms, they usually have a higher bulk factor which sometimes leads to wrinkling. It is practical to use only a low percentage of filler in the molding resin because of the felting nature of the cellulosic fibers; however, the resin can be pigmented and the preforms can be dyed for decorative effects.

Production cycles

Production cycles depend upon the following factors: 1) the weight of the preform; 2) the number of roving cutters; and 3) the amount of hand work required. Where difficult shapes are encountered, or where high quality is required, the production cycles may be 20 to 30% longer than average.

For quality work, the majority of molders cut roving at about 1 lb./min. per cutter. While the cutter can cut fibrous glass at several times this rate, the uniformity of preforms falls off considerably at the higher cutting rates. Where lower quality preforms can be tolerated, many molders cut at the rate of 2 to 3 lb./minute. These cutting rates apply to both the plenum chamber and the directed fiber methods.

In actual practice, the full capacity of the preform machines is seldom used, because so much depends on the ability of the operator to keep up with the speed of the machine.

Recent developments

Plenum chamber: A new high-speed plenum chamber type preform machine (I. G. Brenner Co., Newark, Ohio) which incorporates a self-contained curing oven and an automatic cycling system was made available last year. The heart of the machine is a rotating drum on which four turntables, each carrying a preform screen, are mounted. Each preforming station indexes clockwise 90° at a time through various manufacturing operations.

On lightweight preforms (3½ oz.) this machine can produce as many as 150 preforms an hour. On heavier preforms (1½ lb.), 50 preforms/hr. can be produced. At present, the limiting factor is the time it takes to cure the binder. Added oven capacity or new developments in preform binders could permit higher rates.

Directed fiber method: The largest preform machine of any type in operation is a directed fiber unit (Erie Engine & Mfg. Co., Erie, Pa.) installed at the Molded Fiber Glass Boat Co. This machine has a 205-in. turntable. After the fibers are deposited, doors are closed over the preform and it is cured in place without reducing the suction or transferring the screen.

An automatic binder spray system has recently been added to several large directed fiber machines.

Water slurry method: A highly mechanized variation of the water slurry process is available (Pressurform Co., Swarthmore, Pa.) Preforms having a variable cross-section may be produced.

The process is based on the use of a fluid slurry. The initial fluid slurry involves only an organic component and water. The chopped glass roving cut to any desired length, up to 1 in., is added to the organic slurry just prior to loading the charge into a preforming chamber.

The ratio of glass roving-to-organic fiber depends upon the performance requirement of the end-product. The machine controls are adjustable to provide from 25 to 95% chopped glass content in the preform. As opposed to the screen method described above, the preforms in this operation are made in pairs of ventilated matched metal molds.

Preforming cycles as fast as 30 sec. are possible and they rarely exceed 2 minutes. The preforms contain approximately 50% residual moisture. Oven-drying cycles will vary with section thickness, but usually range from 45 to 90 minutes. Molding is done by customary matched die techniques. Although a "pinch off" is not required to trim excess material because of the closely controlled dimensions of the preform, some sort of resin seal is highly desirable.

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Vulcanized fibre

By R. W. Wilhelm*

A pure, dense, cellulosic material with outstanding electrical insulation properties and high mechanical strength, vulcanized fibre was first produced some 100 years ago. Today it is widely used in electrical insulation, luggage, abrasive backing, high strength textile bobbin heads, materials handling equipment, railroad track insulation, athletic guards, etc. One of the newest applications is in a special grade of thin tape for control purposes in automatic data processing or machining equipment.

Chemistry

Vulcanized fibre is produced by the chemical action of a zinc chloride solution on a saturating grade of absorbent paper made from either cotton rags or wood pulp containing a high alpha content. The zinc chloride causes the individual cellulose fibers to swell and become covered with a layer of gel. After the zinc chloride is removed, the gelatinized cellulose fibers—or layers of fibers—bond together when subjected to heat and pressure under carefully controlled conditions. No added adhesive, resin, or other binder is needed.

Forms

Sheets can be made from a single ply of paper to produce a final thickness of 0.0025 in. or from multiple plies to produce sheets up to ⅛ in. thick. In the thickness range of ⅛ to 2 in., sheets are made by wrapping a predetermined number of layers of paper on a large cylinder; after vulcanizing, the tube is cut in half to produce two sheets.

Tubes are made on mandrels and rods are produced from square cross-sectional strips cut from sheets and ground to the required diameter.

Sheets, tubes, and rods can be readily machined and formed. Recommended practices for fabricating vulcanized fibre by cutting, punching, tapping, milling, shaping, sanding, etc., are described in a publication available from the National Electrical Manufacturers Association (NEMA).[1]

Properties

Vulcanized fibre has outstanding arc resistance and high structural strength per unit area. In thin thicknesses it possesses high tear strength, smoothness, and flexibility. In heavy thicknesses it resists repeated impact and has high tensile, flexural, and compressive strength. It is unaffected by normal solvents, gasoline, and oils.

The moisture absorption of vulcanized fibre is high and the dimensional stability is affected by humidity when not protected by easily applied moisture-resistant coatings.

A special grade of vulcanized fibre, recently developed, provides high tensile strength, high tear strength, low stretch, and opacity to light. This grade is used in the control tape previously mentioned.

Also recently developed is a flame-resistant grade which gives designers a nonburning structural material that has the ability to contain a fire to the source. Main use of the grade is in formed flame barriers in computers and for making flame-retardant materials handling equipment, waste containers, etc.

Grades

The following summary of basic grades, as described by NEMA, also presents a broad view of the scope of uses for vulcanized fibre:

Electrical insulation grade is primarily intended for electrical applications and for others involving difficult bending or forming operations. It is sometimes referred to as fishpaper.

Commercial grade, sometimes referred to as "mechanical and electrical grade", possesses good physical and electrical properties and fabricates well.

Bone grade has greater hardness and stiffness as well as higher specific gravity. It machines smoother with less tendency for the plies to separate during machining.

Trunk and case grade conforms to the mechanical requirements of "commercial grade", but has better bending qualities and smoother surface.

Flexible grade is made sufficiently soft by incorporating a plasticizer to make it suitable for gaskets, packing, and similar applications. It is not recommended for electrical use.

Abrasive grade is designed as the supporting base for abrasive grit for both disk and drum sanders. It has exceptional tear resistance, ply adhesion, resilience, and toughness.

White tag grade has smooth clean surfaces and can be printed or written on without danger of ink feathering.

Bobbin grade is used for the manufacture of textile bobbin heads. It punches well under proper conditions, but is firm enough to resist denting in use. It machines to a very smooth surface.

Railroad grade is for use as railroad track joint, switch rods, and other insulating applications for track circuits.

Hermetic grade is used as electric motor insulation in hermetically sealed refrigeration units. High purity and low methanol extractables are essential because it is immersed in the refrigerant.

White grade is recommended for applications where whiteness and cleanliness are essential requirements.

Shuttle grade is designed for gluing to wood shuttles to withstand the repeated pounding received in power looms.

Pattern grade is made to have best dimensional stability and least warpage for use as patterns in cutting cloth, leather, and similar materials.

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* Application engineer, National Vulcanized Fibre Co., Wilmington, Del.

[1] "Recommended practice for fabricating vulcanized fibre," publication VU2-1949, NEMA, 155 E. 44th St., New York 17, N.Y.

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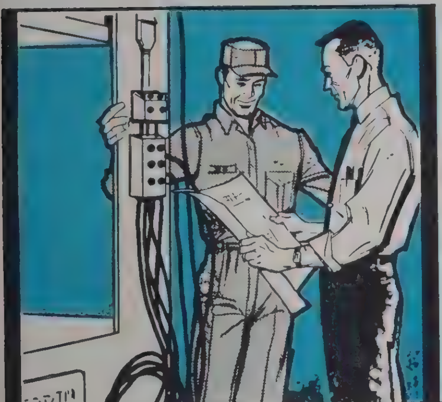

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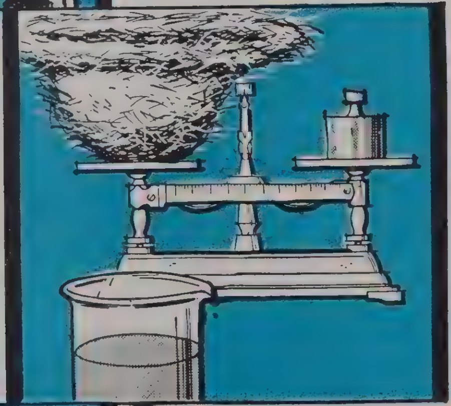

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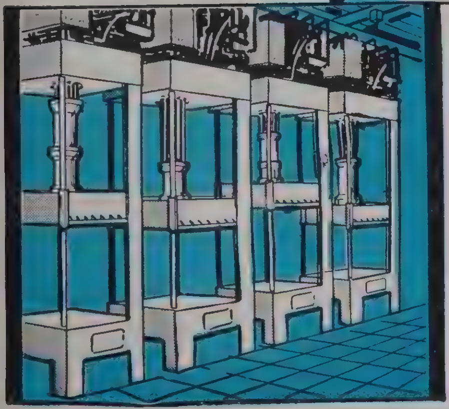

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Molding reinforced plastics

To keep pace with the fast-moving field of reinforced plastics, the Editors have expanded this section on molding techniques to cover the more important processes in use today, including bag molding, matched-metal molding, filament winding, centrifugal molding, premix molding, and spray-up molding.

BAG MOLDING

By Harry T. Douglas*

With the advent of woven roving adaptable to making contact molded parts with high enough glass content to provide adequate strength, the use of bag molding for commercial items has declined. So little is heard anymore of this venerable technique, that many will be surprised to learn it is still responsible for a large proportion of the dollar volume, perhaps as much as 30 percent, done by the entire reinforced plastics industry.

Most bag molding exists in the aircraft, electronic, marine, and missile industries, as well as in the plants of certain specialized subcontractors producing high-quality defense items under the shroud of security restrictions.

Bag molding is the process usually used where the ultimate in physical properties and strength-weight ratios are the primary considerations. Radomes, wing sections, fairings, fin and wing tips, missile noses, and sonar domes are examples.

Bag molding, from the standpoint of rate of production, is faster than contact molding but slower than rubber plunger or matched die molding. Adequate molds can be made quickly from cast or laminated plastics or sheet metal, any of which facilitates getting into production faster than do matched metal molds, which require a long time to machine. However, as in any process, production speed and part quality are usually consistent with the type of tooling used.

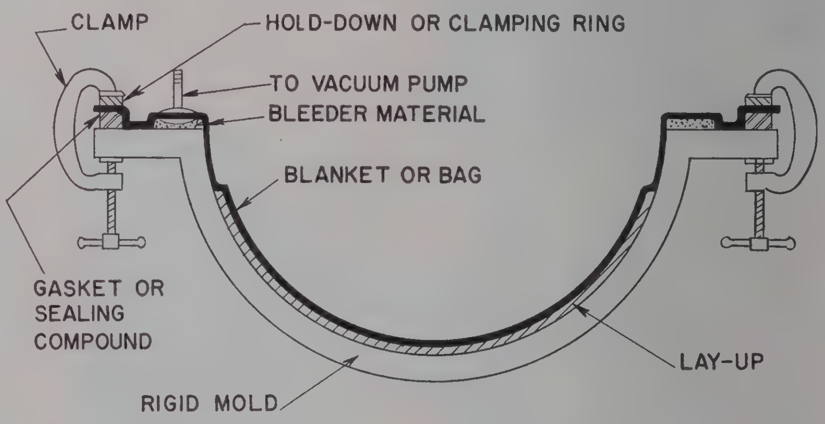
Bag molding, in addition to its use as a production technique, is sometimes used as an interim process while tooling is under way for matched die molding.

In many cases, the design of a part, by virtue of size or shape, will not permit the use of matched dies and a feasible production technique would then be the bag method. The molds for bag molding are more expensive than contact molds but less expensive than matched dies.

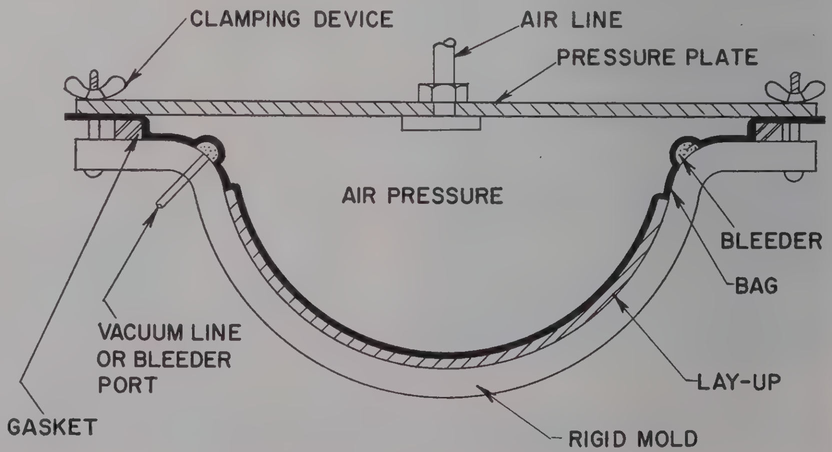
Bag molding processes

Bag molding may be defined as a process in which a flexible bag or blanket is used to apply pressure against a lay-up while it cures. "Lay-up" is the term describing the uncured part or laminate to be molded. It is derived from the fact that in this process the part is "laid up" by placing layers of mat or fabric in the mold by hand. There are many varieties of bag molding but these can be classified into two basic forms: a) vacuum bag molding and b) pressure bag molding.

Vacuum blanket molding: First, the part to be molded is laid up in the mold. Then, the bleeder material (coarse, fibrous, porous material such as hair felt or burlap) is placed around the lay-up, leaving a small gap between the lay-up and the bleeder material. The gasket is then put on the mold. The bag is laid over the mold. Hold-down or clamping rings are set in place and clamped tightly to the mold with C-clamps or their equivalent. Next, the vacuum is



TWO MAJOR TYPES OF BAG MOLDING: Vacuum blanket molding (above), in which air is exhausted from between mold and bag, thereby bringing pressure to bear on laminate; and pressure bag molding, (below) in which pressure plate and air pressure are used



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* Executive vice pres., Lunn Laminates, Inc., Huntington Station, N. Y.

* Recent Developments and References were prepared by the editors.

drawn, exhausting the air from between the mold and the bag and thereby bringing atmospheric pressure to bear on the laminate. The bleeder material serves as a porous and absorbent path which carries the air to the vacuum outlet in the bag and also absorbs any excess resin which flows from the laminate.

Pressure bag molding: Pressure bag molding is similar to vacuum bag, except that a pressure plate is substituted for the clamping ring, thus providing a cover for the mold. Pressure can then be admitted to the assembly supplementing the atmospheric pressure obtained by the vacuum.

Autoclave molding: Autoclave molding is basically no different from pressure bag molding. The autoclave is just another method of applying additional pressure.

Materials for molds: The molds for bag molding range from contact molded polyester laminates to machined steel. Cast plastics, sprayed or electroformed metal, cast aluminum or steel, and sheet metal weldments are the usual mold materials. Bags or blankets may be cellophane, polyvinyl alcohol films, neoprene, or rubber.

MATCHED-METAL DIE MOLDING

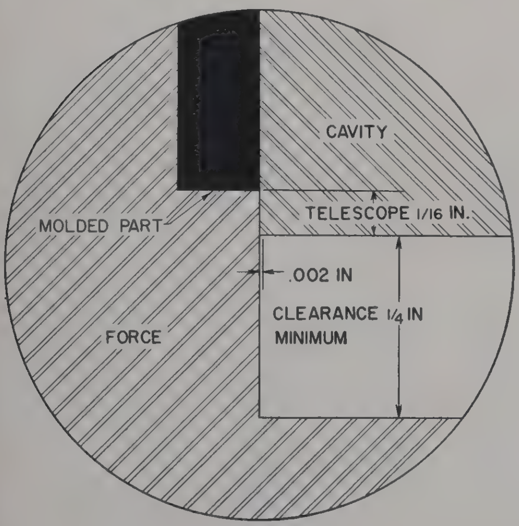
By R. S. Morrison[*]

This article will concern itself entirely with production by means of matched-metal, positive-pressure, heated dies in hydraulic presses, using polyester resin and either fibrous glass mat or preform for reinforcement. This method produces more reinforced plastics products by weight than any other production method.

Typical dies used are positive-pressure matched-metal, steam-heated dies. Since two distinct materials are used in producing mat- or preform-reinforced plastics, the dies must form and hold the fibrous glass reinforcement while the pressure exerted by the dies causes the liquid resin to flow through and completely impregnate the fibrous material. To secure the proper proportion of resin-to-fibrous glass at all points in the molded part, the fibrous glass must not flow with the resin.

Polyester resins not only flow readily at room temperature, but become even more fluid when first heated. Molding dies must therefore be carefully constructed to contain the resin in order to maintain the pressure exerted by the press. Pressure on the resin forces the air out of the preform or mat and also prevents the styrene monomer in the resin from boiling. Either trapped air or styrene vapors will cause porosity. Poor resin distribution and lack of pressure can cause large dry spots in the molded part where the resin did not penetrate.

Properly constructed matched-metal dies telescope within each other to place the resin under pressure in the same way that fluid is compressed by the piston in a hydraulic cylinder. These telescoping "pinch-off" edges must be fitted closely so that little or no resin can escape during the molding operation. Clearance of about 0.002 in. is maintained with a telescoping distance of from 1/16 to 1/8 inch.



CROSS-SECTION of simple mold illustrating a telescoping pinch-off. Telescoping edges are fitted closely so that little or no resin can escape during molding

Materials for construction: Matched-metal dies should be made of flame-hardenable steel wherever possible or should be a flame-hardenable alloy cast iron. Steel castings have not given good results. Cast steel shrinks about 1/4 in./ft. as compared to 1/8 in. or less for cast iron. This greater shrinkage causes porosity which cannot be tolerated in dies heated by steam.

Molding and curing

In molding parts of fibrous glass-mat or preform-reinforced polyester resin, a pressure of 100 to 150 p.s.i. on the molded surface is usually adequate. Molding temperatures average between 220 and 250° F., depending on the size of part and the flow needed.

Small thin parts where resin flow is limited can be cured rapidly at temperatures of 265° F. in 1½ min., but exceptionally large or thick parts require far longer resin flow, so the die temperatures are held down, in some cases as low as 215° F., reducing catalyst concentration.

Mixing the resin

Most polyester resin used in this type of molding contains inorganic fillers such as china clay, calcium carbonate, or calcium sulphate. The molder buys clear resin and adds styrene, fillers, pigments, catalysts, and possibly other ingredients, just before using. Filler concentrations of from 25 to 40% of total mix weight are usual. Up to 40% filler physical properties are fairly constant, though reverse impact resistance drops about 20 to 25 percent. A typical mix for medium-sized auto parts is:

Selectron 5158	330 lb.
ASP-400 china clay	150
Styrene monomer	36.5
Benzoyl peroxide catalyst	2.75
Total weight of batch	519.25 lb.

Styrene is first added to the resin

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[*] President, Molded Fiber Glass Body Co., 4601 Benefit Ave., Ashtabula, Ohio.

pments...Recent Developments...Recen

A flame-retardant fibrous glass-reinforced compound (*Glastic Grade UMG 1500,* The Glastic Corp.), used for the molding of electrical insulating parts, is recognized by Underwriters' Laboratories as acceptable for sole support of current-carrying parts at temperatures ranging up to 150° C.

A glass-reinforced polyester molding compound (*Thermaflow 105,* Atlas Powder Co.), suitable for most structural applications, is at least 20% lower in cost than similar quality molding compounds . . . provides good surface smoothness and gloss and exceptionally uniform strength throughout the molded part.

In a new process for custom molding reinforced plastics (The Cimastra Div. of The Cincinnati Milling Machine Co.), pigmented fibers are molded with resins of the same or contrasting shades. Varied cross-sectional thickness can be specified, and sharp radii, flanges, and intricate shapes can be produced because the critical resin-reinforcement ratio will be maintained for needed strength.

A special coating (*Super-Hardcoat,* Resolite Corp.) for structural fibrous glass-reinforced panels (Resolite Corp.) increases weatherability, resistance to erosion, and color stability by several additional years . . . is a specially formulated clear, acrylic lacquer of extreme hardness and impermeability.

Fibrous glass-reinforced panels (*Tropiglas,* produced by Russell Reinforced Plastics Corp., marketed by Naugatuck Chemical), made with a partially polymerized mixture of methyl methacrylate (*Lucite Sirup,* Du Pont), are suggested for sun deck roofing, partitions, and glazing uses . . . this methacrylate "sirup" withstands higher heat and has less creep than polystyrene or methacrylate.

A fibrous glass-reinforced polarizing light panel (Owens-Corning Fiberglas Corp.) gives high-efficiency, glare-free illumination . . . uses reflected and refracted polarization to achieve brightness control and uniform light distribution, which permits a high level of illumination with reflected glare controlled in the single panel.

Mineral filled glass-fiber reinforced alkyd molding compound, classified as MAI-30 under military specifications, has been introduced (*Glaskyd 2051,* Glaskyd, Inc.) . . . has a nominal impact strength of 3 ft.-lb. per in. of notch.

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and then the filler. This combination is mixed for 80 min., and the catalyst, mixed with an equal weight of styrene, is added and the batch is mixed for another 20 minutes. After mixing, it is desirable to let the batch set about 2 hr. before using, to allow air mixed in the resin to come to the surface and to permit more complete dissolving of the catalyst. If pigment is desired to color the mix, it is added shortly after the filler is added to the resin. The catalyzed mix should be used up the same day as mixed. Viscosity of the mix will increase at room temperature until eventually the batch will gel and harden, and be unusable.

Molding techniques

In molding, two methods of applying the resin to the mat or preform are used. Whenever possible, the resin is poured onto and distributed over the mat or preform outside the press while the previous part is being cured in the dies. This reduces press-open time. This method can be used to advantage where multiple layers of mat are used. After the resin is spread, the last layer of mat is put on and the operator picks up the sandwich and lays it in the dies.

The other method involves placing the fibrous glass reinforcement on the bottom die in the press and then distributing the resin over the fibrous glass. This is quite necessary in large complex preforms and is also used when it is important to keep the part as free from off-color particles as possible.

Pour pattern

The proper pour pattern for resin distribution over the reinforcement can be very critical and important in exceptionally large parts. Improper pour pattern can cause porosity and resin-starved areas. Unfortunately, proper pour pattern cannot be worked out in advance, but must be developed by trial and error. Consequently, during the early molding of large parts, the scrap rate can be very high.

Gel time

The viscosity of the resin mix and its gel time are critical in matched die molding, especially with large parts where considerable time is required to distribute the resin. To increase gel time, the catalyst is reduced, which means a longer molding time.

Advantages

The advantages of production in positive-pressure, matched-metal dies are as follows:

1) *Reasonable cost:* Not including tool amortization or setup costs, the cost per pound of the finished part trimmed to size will run from 40 to 70% lower by this method than by other methods.

2) *Higher quality:* The die surface of both the male and female die are duplicated on the molded part, giving excellent surface finish on both sides.

3) *Elimination of trimming op-*

erations: A shearing action of the telescoping pinch-offs not only contains the resin, thus eliminating porosity, but also molds the part to the exact size and cuts off the flash at the same time.

4) *Exact duplication of parts:* With careful preforming and molding techniques, all parts coming from the same set of matched-metal dies will be exact duplicates. Other molding methods cannot control material thickness and other dimensions to the accuracy usually desired in parts being assembled to other parts.

5) *High strength:* The pressures made possible through the use of hydraulic presses permit high glass concentrations of up to 50 percent. Most parts requiring high strength and good appearance contain 35 to 40% glass by weight and strengths obtained will average from 60 to 100% higher than strengths obtained by other molding methods. Strengths may vary, however, in some deep-draw parts because of the difficulty of achieving uniform distribution of the glass fibers in the molding.

6) *Completeness of cure:* With dies heated in the range of 225 to 260° F., the resin can be completely cured; this completeness of cure is another reason for the high strength properties mentioned above. This complete cure also contributes to dimensional stability.

7) *The use of fillers to reduce shrink:* Matched-metal die molding permits the use of inorganic fillers, which are difficult to use with other methods. These inorganic fillers reduce the shrinkage of the resin during cure, produce smoother surfaces than would be obtained with unfilled resins, and improve certain physical properties. Fillers can also result in a substantial cost reduction of the resin mix, often at some sacrifice in strength-weight ratio or resistance to filler-attacking chemicals.

8) *High rate of production:* Production rates of simple parts weighing up to 3 lb. will run as high as 200 parts/8-hr. shift in a single-cavity set of dies in a suitable, properly controlled, press. A team of six people, including two preform operators and four press operators, can produce fifty 160-lb. boat hulls in an 8-hr. shift for a labor cost of less than one man-hour per boat hull, including material preparation.

Limitations

There are, of course, some disadvantages and limitations to the technique.

1) *The high capital investment in equipment:* A reasonably adequate custom molding shop would have at least $100,000 invested in equipment, not including buildings, to give it sufficient capacity to carry the overhead of maintenance, technical, supervisory, engineering, sales, and management personnel. This equipment is very specialized and cannot be adapted from conventional molding equipment nor is it suitable for most other forms of molding.

2) *The high cost of matched-metal dies:* Matched-metal dies will run from 300 to 600% higher in cost than plastic dies completely set up for production. Compound curvature matched-metal dies are relatively more expensive than dies not requiring duplicator machining.

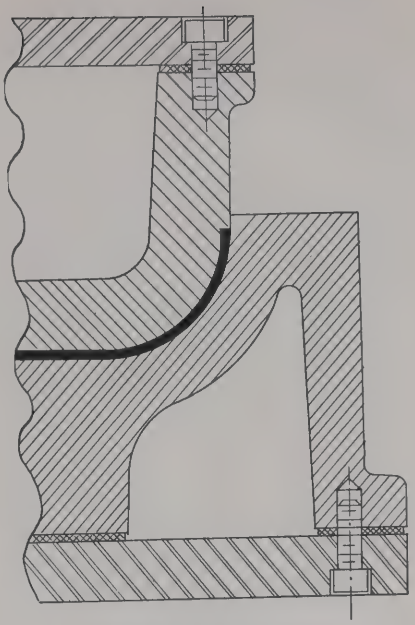
3) *Time required to produce tooling:* It will take from 3 to 6 times as long to produce matched-metal dies as it will plastic dies.

4) *Sources of matched-metal tooling:* The equipment required to make large matched-metal dies having compound curvature is scarce and available only in certain areas of the country.

5) *Alterations on matched-metal dies:* It is difficult and expensive to make alterations; thus it is very important that the design of the part to be made is thoroughly tested and stabilized before the dies are constructed.

6) *Limitation in part design:* No undercuts can be molded in matched-metal dies; these are possible in some other forms of tooling for fibrous glass-reinforced plastics production.

7) *Scarcity of technical personnel experienced in matched-metal-die production:* There are very few people who have both the over-all knowledge and experience needed in this specialized field. This knowledge and experience are best obtained on the job, an expensive and time-consuming method of learning.



CROSS-SECTION VIEW of a set of positive-pressure matched-metal, steam-heated molds used for matched-metal molding of reinforced plastics

Because of the advantages listed above, many fibrous glass-reinforced plastics parts have been successfully produced which would not have been attempted by other methods. This is particularly true of parts used in assemblies where thickness tolerance is critical. Lower unit costs and higher production rates make parts produced by this method attractive where requirements are for several hundred pieces per week.

Consistent quality and dimensional control will allow these parts to be assembled to others in assembly-line operations where deviation from predetermined rates could not be tolerated. Higher filler content of press molded parts eliminates crazing at elevated temperatures so that conventional baking enamels may be used if desirable. Successful production of boat hulls and automotive underbodies in matched-metal dies practically eliminates limitations due to size; in fact, the possibility of molding large parts in a single piece suggests many new applications where an assembly of several smaller pieces might be required if materials other than the fibrous glass-reinforced plastics were the ones to be used.

FILAMENT WINDING

By J. P. Bernd* and L. A. Niedfeldt†

In the reinforced plastics fabrication method known as filament winding, continuous strands of glass roving are precisely positioned by machine winding on a mandrel of suitable shape. The roving may be impregnated with resin before, during, or after the winding process. The mandrel may be of any suitable rigid material such as plastics plaster, or steel or other metal; it may be in one piece or several pieces and left permanently in place or later removed; or it may be of some fusible material such as salt, wax, or low melting alloy, which can be melted and poured out of the cured reinforced plastics shell.

In production, the mandrel may be rotated around one or more axes, the roving may be guided by cam-operated mechanisms onto a stationary mandrel, or a combination of these motions may be used.

Numerous patents on filament winding date back to the early 1900's, but the process has assumed commercial importance only within the past decade.

The importance of the angles at which the reinforcing filaments are wound is presently being intensively investigated. In general, this factor will vary according to design load and/or strength requirements. To develop maximum hoop strength of a cylindrical vessel, the angle must approach 90° or a straight circumferential winding.

Two basic types of filament winding are presently in use: helical and biaxial. Helical winding utilizes a varying pattern to optimize strength in either the longitudinal or the hoop direction; biaxial winding produces an essentially longitudinal and circumferential pattern with variations to accommodate specific loads.

The Strickland B Process for filament winding, developed in 1955, makes possible the production of objects of varying cross-section and asymmetry. It differs from previous techniques in that the filaments are arranged in alternating radial and longitudinal patterns. Thus the number of fibers in each direction can be specified to correspond to major loads, resulting in more efficient use of the material and greater weight savings. Because of the high uniformity of laminate composition and precise control of laminate thickness, the Strickland B Process is ideally suited to such constructions as radomes.

Perhaps the largest use of filament winding in recent years has been in spherical pressure vessels for containing oxygen and other gases on aircraft. Such vessels do not shatter or burst into dangerous fragments when ruptured by internal or external forces. Since they are composed of a multitude of intermeshed filaments, rupture is limited to the area of failure and there is no "shrapnel" effect as with metal vessels.

Thus, the designer has available a material which not only has a higher strength/weight ratio than SAE 4130 heat-treated steel, but also one with which normal factors of safety can be applied without concern for possible destructive consequences.

Of major consideration in the application of a material is its ease of fabrication and the effect of fabrication problems upon its performance. Metal pressure vessels are produced by either casting, forming, and/or welding techniques. These processes are all subject to operator and equipment variables, with rigid quality control necessary to provide adequate safety. However, the production of a filament wound vessel is an automatic machine process which requires a minimum of production personnel. Each filament is machine guided into its proper position and there is precise duplication from vessel to vessel. Under these production conditions, quality control can be minimized with assurance that absolute consistency is being met.

Rocket motor cases

Two of the advantages of filament winding (light weight and lower cost) are being applied in the production of the cylindrical vessels which serve as cases for rocket motors using solid propellant fuels. As rocket motors become larger and larger, the cost and weight of a metal case becomes prohibitive. At the same time, since the propulsive efficiency of a rocket is a direct function of the dead weight of the missile, it is apparent that a lighter material would be feasible even if it were more expensive —a factor that can be called the "cost/weight" ratio. Filament-wound motor cases are both lighter and less expensive than their metal counterparts, so rocket designers gain on both counts.

Advantages

The several advantages of filament winding can be summarized as follows:

1) It uses inexpensive glass roving for reinforcement. All other forms of glass reinforcement such as mat and cloth are made from roving and additional

TABLE I: Comparison of physical properties*

Property (ultimate)	*Filament wound laminate, unidirectional*	*Cloth laminate*	*Filament laminate (5 ply)*[1]	*SAE 4130 Heat-treated steel*
Flexural strength, p.s.i.	200,000	58,000	60,000	125,000
Flex modulus, p.s.i.	7.5×10^6	2.3×10^6	6.5×10^6	29×10^6
Tensile strength, p.s.i.	200,000	48,000	81,000	125,000
Tensile modulus, p.s.i.	7.5×10^6	2.5×10^6	9.5×10^6	29×10^6
Bolt bearing strength, p.s.i.	40,000	65,000	43,000	180,000
Glass content, %	85	62	84	
Strength/weight ratio	2,500,000	750,000	750,000	400,000

* Comparison made at room temperature. Comparisons at elevated temperatures will depend upon the laminating resins involved. See also Fig. 1, p. 488.

[1] 3 plies running in direction of stress, 2 plies across.

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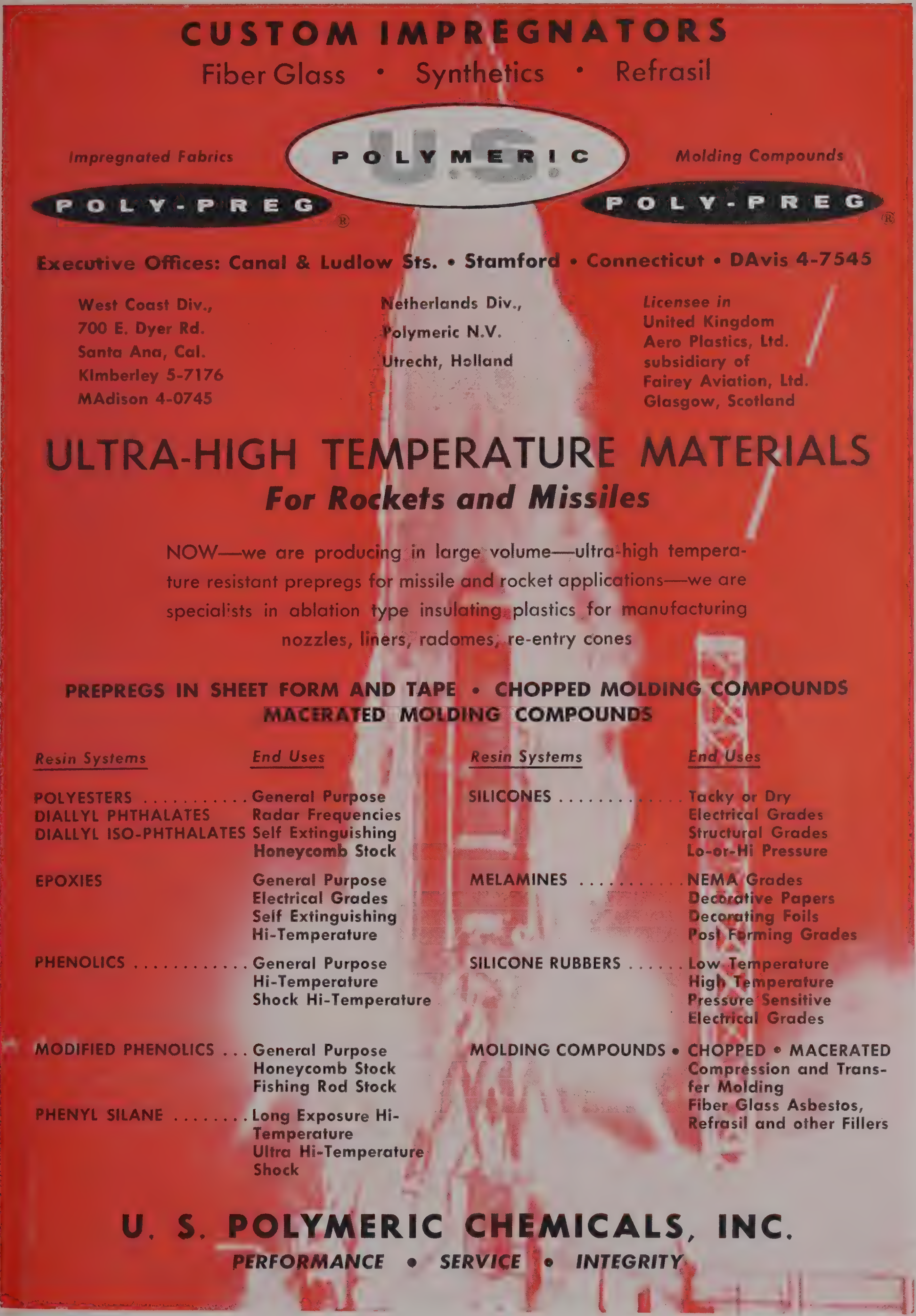
*Chief engineer, Muskegon Defense Products and †Sales mgr., Defense Products Div., The Brunswick-Balke-Collender Co., 1700 Messler St., Muskegon 82, Mich.



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EPOXIES	General Purpose Electrical Grades Self Extinguishing Hi-Temperature	MELAMINES	NEMA Grades Decorative Papers Decorating Foils Post Forming Grades
PHENOLICS	General Purpose Hi-Temperature Shock Hi-Temperature	SILICONE RUBBERS	Low Temperature High Temperature Pressure Sensitive Electrical Grades
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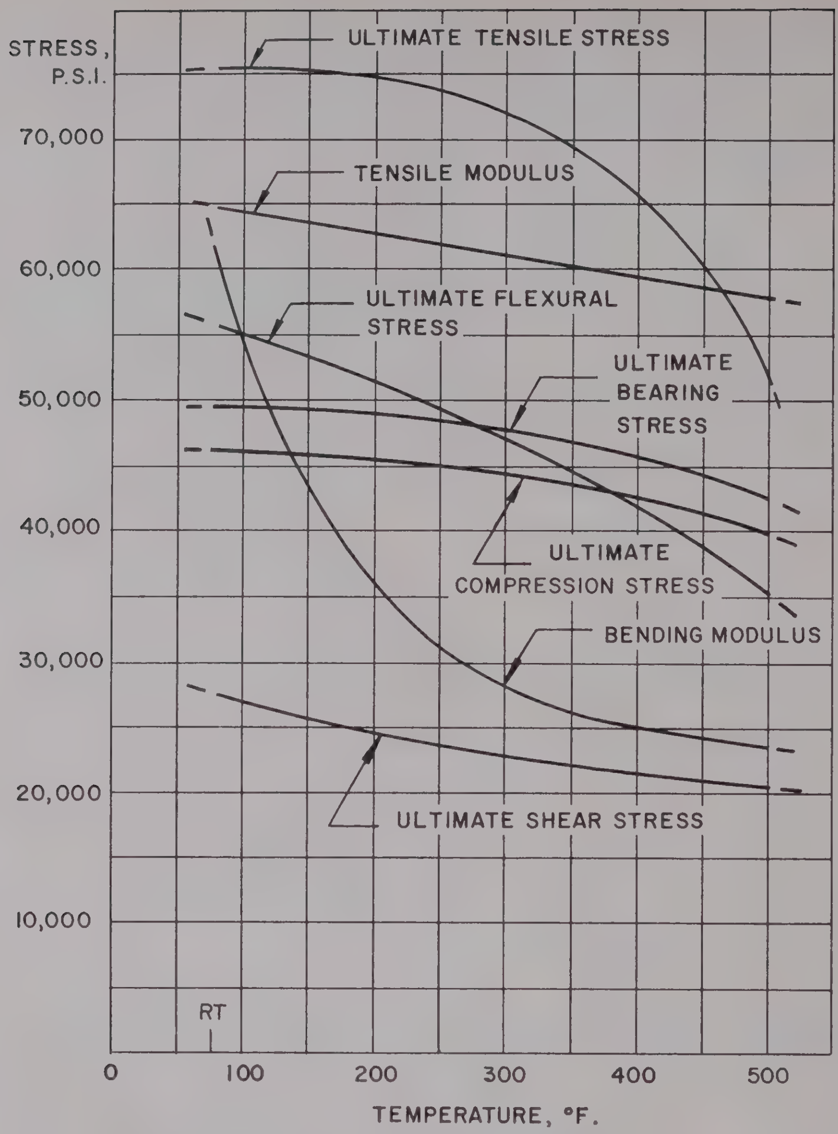


FIG. 1: Variations of physical properties with temperature for a filament wound glass-polyester structure. The laminate was 5-ply, with 3 plies running in the direction of load and 2 across

steps are needed to produce the final reinforcement.

2) It offers higher strengths than other forms of reinforcement because it uses continuous strands wound into layers and thus avoids the abrading action under load of woven warp and fill strands. The fibers are straight, rather than being bent by being woven, which eliminates bending stresses in the individual filaments.

3) The fibers are wound on the mandrel under controlled tension. This allows for preloading the fibers and assures that they load up uniformly in operation. Having all fibers uniformly loaded prevents the progressive failure of laminates due to some fibers not absorbing their share until other fibers have been overloaded.

4) A high degree of uniformity can be attained by accurate control of the filament impregnation. Machine winding assures indexing and location of the fibers. Resin content can be held to ±½%, which cannot be equalled by any other process.

5) Uniformity can be further improved by controlling the final grinding process by the electrical thickness of the plastic rather than the physical thickness. This is accomplished by controlling the grinder with an interferometer.

6) In radome production, minor adjustments can be ground into the mandrel to compensate for the effects of radome shape or hardware on the radar beam. Thus the radome is compensated as it comes off the mandrel.

7) Because of its high uniformity and the feasibility of correcting in advance, filament winding can eliminate or substantially reduce the expensive electrical testing of radomes.

8) Labor cost reductions are possible because the entire process is performed by machines. Operators are necessary only to control, load, adjust, and unload machines.

9) Thickness changes can easily be made.

Limitations and disadvantages of filament winding include:

1) It offers virtually no advantage for flat plates or open bodies.

2) It is practically impossible to wind reverse curves or indentations. Flats can be wound but should be avoided if possible.

3) Because the high strength depends upon the continuous filaments, drilling, cutting or otherwise interrupting the structure should be avoided. Bolt bearing properties can be improved by laminating glass cloth pads between the layers of filaments.

4) Tooling for prototypes or short run production can be prohibitively high.

Filament winding is adaptable to virtually any shape of positive curvature. However, the complexity of tooling required to wind some shapes may more than offset the advantages.

Summary

Filament winding offers the designer the advantage of uniformity, machine controlled reproducibility, greater strength, greater rigidity, and potential cost and weight savings.

Filament winding is not limited to glass roving, but can be used with any type of filament in combination with virtually any type of resin binder.

It is best suited for cylinders, spheres, and conical bodies of revolution but has been adapted to many shapes ranging from bowling pins to paravanes.

It is predicted that the more stringent electrical, mechanical, and thermal requirements of the aircraft and missiles of the future will make filament winding more desirable if not mandatory in many reinforced plastics applications.

CENTRIFUGAL MOLDING

By A. Wiltshire*

Centrifugal molding, as the name implies, uses the centrifugal force created by a spinning mandrel to turn out polyester-fibrous glass tubular parts with constant results from part to part, and from lot to lot. Basically, fibrous glass mat is first wrapped around a metal stovepipe and inserted into a mandrel. The stovepipe is then removed and as the mandrel starts to revolve, a hollow rod through which the resin flows begins shuttling back and forth inside the mandrel.

The centrifugal force on the resin and fibrous glass is maintained under controlled conditions as the resin is warmed to reduce the viscosity to the consistency of water and then on through the gel state to complete cure. By means of this uniform force, it is possible to force all the air out of the fibrous glass mat, thereby resulting in a void-free laminate that will not leak under pressure conditions.

The metal mandrel used to support the resin and glass during the spinning operation is made of steel and is bored and honed to a mirror finish within an accuracy of 0.002 in. on the diameter.

During cure, there is a slight shrinkage, approximately 0.001 in./in. of diameter, of the reinforced tubes away from the mandrel. This shrinkage aids in the removal of the finished part from the mandrel, since only a slight force is necessary after cure to break the tube free. In addition, the fact that the end product is free to shrink as it cures eliminates any shrink stress from being built up in the part. If, in contrast, the tube was molded on the outside of the mandrel, it would not be free to shrink, strains would be set up, and the tube would be difficult to remove.

The finished mandrel must therefore be fabricated taking the shrinkage into account so that the finished diameter of the tube can be held to within 0.010 inch. Tubes

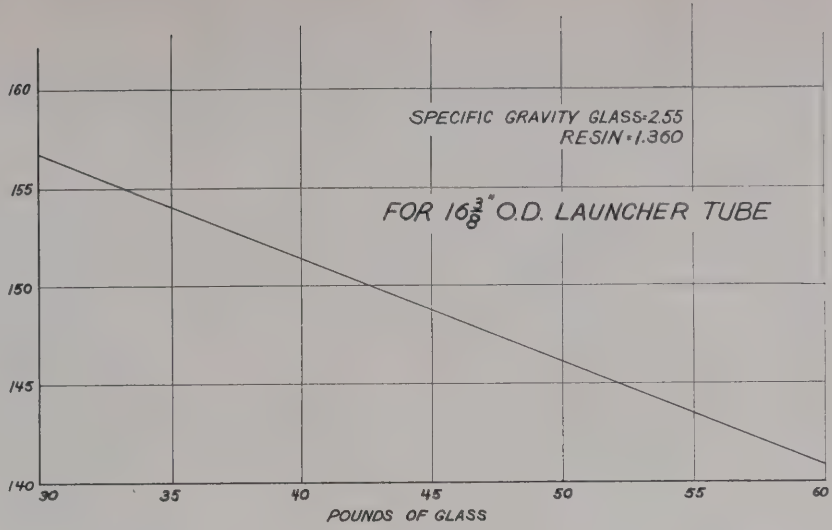


FIG. 1: Quality control curve used to determine correct weight of resin to be injected into the fibrous glass mat in centrifugal molding

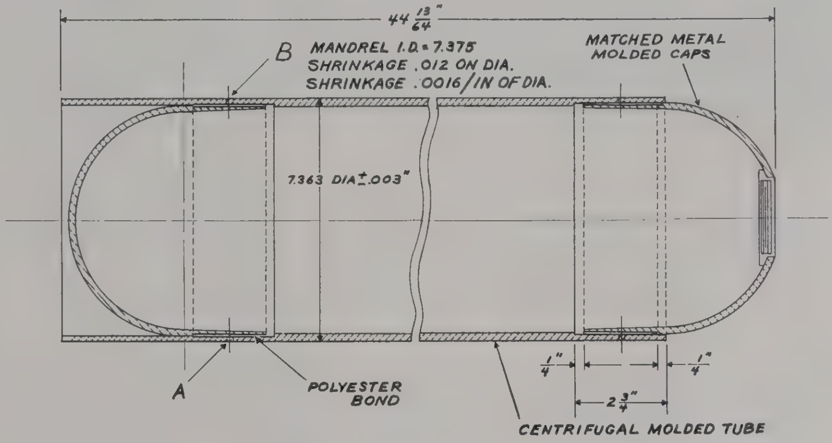
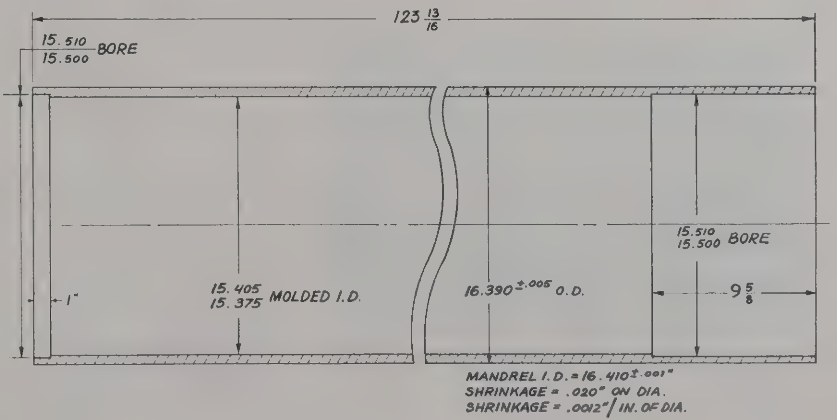


FIG. 2 (ABOVE): Diagram of centrifugally molded water softener tank. Tanks of this type have a cycle life in excess of 500,000 pressure cycles from 0 to 150 p.s.i. Burst pressure on tanks is 600 p.s.i. minimum, so that operating pressure is 25% of ultimate. Note how molded end caps can be bonded to tube by injecting polyester resin under pressure into hole A until flow of resin is obtained from hole B. Holes are then sealed and joints cured with heat. **FIG. 3 (BELOW):** Centrifugally molded torpedo launcher tube, 10 ft. long and with 1 in. wall thickness; wall thickness held to within 0.010 inches. Outside diameter on tubes is 16⅜ inches. Tubes are subjected to internal pressure of about 80 p.s.i. when launched. Since burst pressure of tubes is close to 800 p.s.i., this means there is a safety factor of 10



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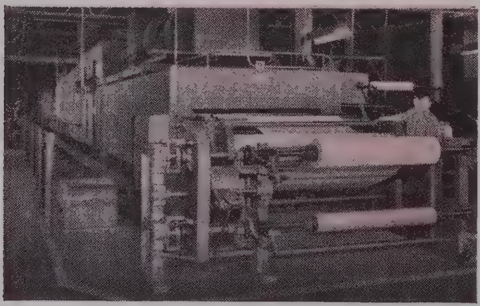

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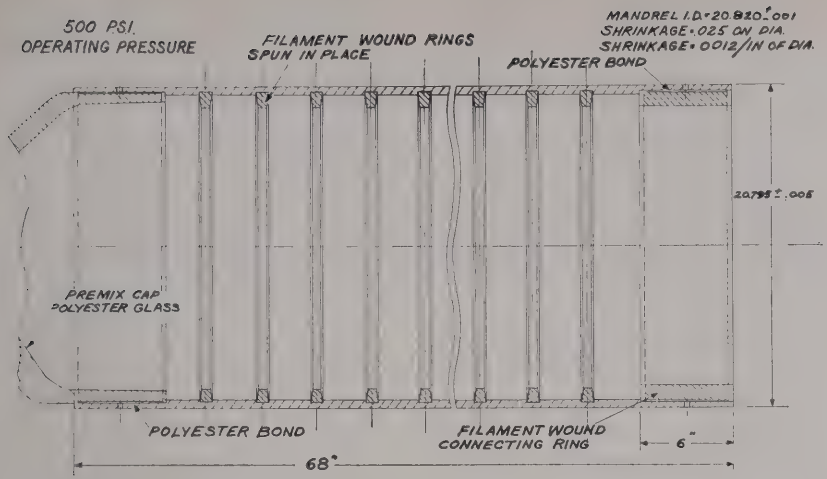

FIG. 4: External pressure tubes have been built to withstand a working load of 5000 p.s.i. in water. In this case, it is necessary to mold-in ¾ by ¾ in. cross-section glass filament wound rings at a spacing of approximately 3⅓ in. in order to be able to resist the unstable condition created by external loading

removed from the mandrel may go out of round due to the low hot strength of the resin used and must be controlled by proper supporting fixtures or by standing the tube on end.

The wall thickness can be controlled to within 0.010 in. in this process. The glass is weighed for each tube and the correct weight of resin to be injected into the center of the mandrel is determined by a quality control curve (See Fig. 1, p. 489).

Cut fibrous glass mat of 2 oz./sq. ft. with glass fibers approximately 2 in. long, and a high solubility binder is used. The resin injected in the mandrel dissolves the binder on the mat, allowing each bundle of glass filaments to relax and pack against the mandrel due to centrifugal force. The ultimate tensile strength of tubes made by this process is about 14,000 p.s.i. with glass content of 25 to 30% by weight. Higher contents of glass up to 35% can be obtained by using acetone spray to pack the glass.

Tubes thus molded can be controlled very closely as to wall thickness and dimensions and are perfectly watertight under pressure and cycle conditions. They have been used as water softener tanks (Fig. 2), torpedo launcher tubes (Fig. 3), and external pressure tubes (Fig. 4), among other applications.

POLYESTER PREMIX MOLDING

By W. O. Erickson*

Lower cost of reinforced-polyester products than can be achieved by mat or preform molding is the major advantage of the polyester premix molding technique. In addition, it permits the rapid molding of parts with varying wall thicknesses, intricate contours, and molded-in inserts.

This method does not give as good physical properties as other reinforced polyester molding techniques; however, properties are more than adequate to meet the requirements of many applications—including automotive heater housings, electrical outlet boxes, air conditioning housings, and pump impellers. Serviceability at low cost rather than critical physical properties should determine the suitability of the premix method in any given application.

Premix ingredients

Resin: There is no one perfect resin for all premix applications. Part design and service requirements to a great extent govern resin choice. The principal functions of the resin in preform or mat molding are to carry filler throughout the reinforcement and to bond filler and reinforcement; in premix molding, the resin must carry both reinforcement and filler to all parts of the mold and bond them.

Resins for premix molding should have a minimum viscosity of 15 poises—usually the higher its viscosity, the better will be the reinforcement and filler distribution. Styrene or vinyltoluene monomer resins should be in the range of 15 to 200 poises. Diallyl phthalate monomer resins can have as high a viscosity as can be handled because of inherently good lubricating properties. While DAP monomer resins as high as 2500 p. are used in premix, most molders prefer viscosities of 600 p. or less because they can be used without special equipment.

Fillers: Clay, ground limestone or whiting, gypsum, and talc are among satisfactory fillers for premix molding. Clay is the most widely used because it contributes good handling and molding properties. Ground limestone can be used when flow properties are not critical. It has a lower oil-absorption value than clay, permitting higher filler loadings. This reduces the raw material cost of the compound.

Reinforcement: Chopped glass fiber is the most widely used reinforcing material. Other materials such as sisal and asbestos are of interest for specific applications. In premix molding optimum physical properties are obtained with a glass fiber length of ¼ to ½ inch. Fiber lengths in excess of ½ in. have the disadvantage of not dispersing as well in the mix and of being susceptible to a higher degree of degradation during mixing. Chrome- or silane-finished glass is recommended since either finish permits maximum wetting of glass fibers by the resin. For applications requiring minimum water absorption, silane finish should be selected.

Scrap glass, such as trimmings from random mat, can also be used in premix if they are first run through a hammer mill. However, variability of physical and flow properties increase because of less-uniform fiber length. The normal range of glass content is 5 to 35% of the mix. Glass contents up to 20% produce compounds which are fairly plastic, are easily preformed, and flow readily under pressure. When glass content exceeds 20%, the compounds become progressively more fluffy and spring-like; they do not lend themselves to preforming and do not flow as easily.

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*Plastics and Coal Chemicals Div., Allied Chemical Corp., 40 Rector St., New York 6, N. Y.

For uses requiring increased impact strength, but no greater flexural strength and modulus than those of the resin-filler mix alone, straight ¼- to ½-in. long sisal fibers are utilized. They have a lower specific gravity than glass and are less than half the price of glass. The maximum loading with sisal is approximately 20%, with 5 to 10% being in a more easy-to-handle range. The fibers do not wet as well as glass and a noticeable straw-like pattern develops on the molded surface. Some fabricators are taking advantage of this pattern to promote surface configurations made by sisal. However, sisal should not be considered for applications in which water absorption is critical since it absorbs much more water than does glass.

Catalyst: Benzoyl peroxide catalyst is the best all-round premix catalyst.

Pigment: In general, pigments which can be used with polyesters for preform molding are satisfactory for premix. The range of ½ to 3 parts of pigment paste per 100 parts resin is customary.

Internal mold lubricants: The use of internal mold lubricants such as stearic acid and zinc or magnesium stearate is required for satisfactory mold release characteristics. For molding temperatures up to 270° F., stearic acid provides excellent release, and from 270 to 310° F., zinc or magnesium stearate is recommended. Concentration should be 1.0 to 1.25% of lubricant, based on total mix weight.

Mixing equipment

Careful laboratory and production studies have demonstrated that the most satisfactory mixer is a double-blade, rectangular-trough-type kneader equipped with 180° spiral blades. Sigma blades can also be used; however, as there is a tendency for material to ball-up on the center post of a sigma blade, use of the spiral blade is preferable.

There should be a ¼ to ⅜ in. clearance between the blade edge and shell to prevent jamming of blades and excessive degradation of the glass fibers.

The recommended range of blade speed is 20 to 35 r.p.m. If blade speed is too slow, the rate of mixing is reduced and abnormal cycle time results. If, instead, it is too high, the mix becomes overworked, resulting in degradation of the glass fibers and overheating.

The high viscosity of premix compounds creates considerable friction during mixing. This causes a build-up of heat in the mix which, if it becomes excessive, will result in reduced stability, pre-gel of the resin, and considerable loss of monomer in resins containing volatile monomer, e.g., styrene or vinyltoluene. Temperature of the mass should not be permitted to exceed 125° F. In small mixes, heat build-up is ordinarily not a problem; however, in batches of 50 lb. or more, the mixer should be jacketed to provide for the water cooling of the shell.

The suggested procedure for mixing, including approximate cycle time is as follows: 0 min.—add dry filler (clay, limestone, etc.) and lubricant (stearic acid, zinc stearate, etc.) to mixer and start blades; 1 min.—add resin, catalyst, and color to mixer and allow to blend thoroughly; 5 to 20 min.—add glass carefully to prevent agglomeration and consequent poor wetting and dispersion; 20 to 30 min.—glass addition complete, allow to mix thoroughly; 30 to 45 min.—mix complete. After this procedure, dump.

As indicated, the above mentioned cycle times are approximate and should be adjusted to meet the requirements of particular mixes or batch sizes.

The resin-filler mix should be a smooth paste prior to addition of glass. After glass addition is complete, mixing should continue until a thorough dispersion is assured and the glass fibers are well-wetted. Overmixing should be avoided because it results in excessive degradation of the glass fibers and consequent lowering of physical strength.

Because considerable heat of friction develops during mixing, the mix should be dumped into a cellophane- or polyethylene-lined pan or tote box immediately after dispersion is complete. After the mix has been permitted to cool approximately 10 min., it should be stored in a tightly sealed fiber drum lined with polyethylene or cellophane. This is of particular importance when volatile monomer resins are used, because the loss of monomer on exposure will dry a mix and cause it to become unusable in a short period of time.

The mixing equipment may be cleaned with styrene, acetone, methyl "Cellosolve," or methylene chloride. However, methylene chloride is recommended because it is nonflammable. A small quantity of chopped glass added to the methylene chloride helps to remove solid chunks of material. Mixing and cleaning operations should be conducted in a well-ventilated area.

Storage

Various factors affect the storage life of polyester premix compounds, which normally range from 3 to 7 days at 70° F., longer at lower temperatures. The volatile monomer resin mixes tend to become unuseable at a faster rate than the diallyl phthalate monomer resin mixes. The clay mixes are generally more stable than those containing calcium carbonate, although mixes made with the ground limestone form have comparatively good shelf life. Another factor is color—certain pigments, particularly some types of blue, green, and black, reduce stability.

Presses

Almost any standard compression molding press is satisfactory for molding polyester premix compounds. The principal feature to incorporate is rapid closing. From the time the mold is loaded to application of full pressure, no more than 6 to 8 sec. should elapse; otherwise pre-gel may result.

Pressure requirements range

from 500 to 2,500 p.s.i. on the projected area of the mold, depending on draw, complexity of the part to be molded, and presence in the mold of core pins or other obstructions to flow. For simplest parts, involving no obstructions to flow and no more than 1 in. draw, tonnage requirements can be based upon a length-times-width calculation of the mold area perpendicular to the direction of pressure. When the draw exceeds 1 in., area in sq. in. may be calculated as follows:

$$A = WL + 0.1\,WLD$$

where W, L, and D are the width, length, and depth, in inches.

If an existing press does not provide the necessary tonnage it can often be modified by 1) increasing the line pressure; or 2) increasing the ram diameter. If it is feasible to increase ram diameter, it is probable that a higher-volume pump will be required to maintain a high closing speed.

Molding principles

Polyester premix compounds can be molded by compression or transfer methods. Articles manufactured by transfer molding methods do not usually develop a circular strength pattern. The resultant strength is normally lower than that developed by compression methods, and shrinkage tends to be higher. The flow of material through the gate causes alignment of the fibers and produces unidirectional strength. This fact should be taken into account in the design of the mold. The gate should be so designed and located as to provide maximum strength in the direction of maximum stress. Multiple gates should normally be avoided because a weak section will result at the point of knit. The best strength is obtained by gating at the end of a part rather than at the center.

Because of the abrasive characteristics of polyester premix compounds, molds should be made of conventional mold steels hardened by heat-treating, highly polished, and, preferably, chrome-plated.

Type of mold

The type of mold to be used depends upon the part under consideration. Flash, semipositive, and positive molds have been used successfully in premix molding. In general, semipositive molds are recommended since production of parts having the most uniform density and minimum shrinkage requires the material to be under positive pressure at all times. The clearance of the vertical punch entry varies from 3 mils for materials of low glass content to 6 mils for high glass content mixes. The bulk factor of premix materials varies over a rather wide range depending upon glass content. Low glass mixes have a bulk factor of approximately 2 to 1, whereas for high glass mixes, it may run as high as 6 to 1. The mold should be cored for steam- or cartridge-type electric heaters in order to provide uniform heat transfer in both plug and cavity. It should be mounted on insulation to prevent loss of heat by conduction to press members. Knock-out pins can be satisfactorily used, but they should be somewhat larger in area than those used for other molding materials. To obtain proper material flow, easy release from the mold, and molded parts of optimum strength and serviceability, the following design recommendations should be considered:

1) Avoid abrupt changes in wall thickness.

2) Round all corners generously.

3) Avoid extremely thin sections (less than 60 mils) or thin ribs.

4) Avoid undercuts. If an undercut is essential, it *can* be produced in a multiple-piece mold; however, this greatly increases mold cost and often increases cycle time.

5) Eliminate molded-in holes, if possible. When such holes are necessary, it is best to design holes to go partly through the article, then drill out the rest after molding. This permits better flow of glass. If core pins are used, they should be located far enough from the edge to allow the material to knit after flowing around the pin.

6) Sides should be tapered to provide easy removal from the mold.

7) Bosses designed to be tapped for screw attachment or molded-in inserts should be of sufficient diameter to distribute stress adequately.

In charging a mold with polyester premix compound, a certain amount of preforming is desirable to remove air from the charge and to provide the proper flow of material, thus insuring maximum strength in the molded part. Preforming may be accomplished by hand, in an arbor press or hand-operated forming mold, or with a power-operated extruder. Since extrusion aligns the glass fibers in one direction, unidirectional strength results unless a special loading technique is developed. Both ram-type and screw-type extruders are being used satisfactorily. Excessive build-up of heat from friction should be avoided because it may result in pre-gel. Heating the extrusion die to 130 to 140° F. improves the surface of the extruded material.

The closed mold cycle depends upon curing temperature, nature of the resin, and maximum wall thickness of the part. Curing temperatures range from 250 to 300° F. and closed mold time from 30 sec. to 5 minutes. This is a generalization not applicable to special cases requiring modified flow characteristics on account of size, thickness, or shape of a particular article.

Handling and finishing

Proper handling of the cured article after removal from the mold is of the utmost importance. While the part is hot, it is comparatively weak and can easily be fractured or distorted. Simple cooling jigs can do a great deal to prevent warpage during the cooling period.

Most finishing and trimming operations can be performed on standard metal-working equipment. Tools for drilling or milling should be carbide tipped. Cutting is best accomplished on a wet abrasive cut-off wheel. Wet sanding does not create a dust problem, but dry sanding operations should be conducted under a hood equipped with power exhaust, because of the large quantity of fine siliceous dust produced by this operation.

PHENOLIC PREMIX MOLDING

By J. J. Colao*

Because phenolic premix molding is still in the formative stages, to date only reinforced or impact-type materials are being prepared on the molder's premises. Indications are, however, that phenolic molding materials of all types eventually could be prepared by the premix process.

This lowered cost places impact phenolics in a new light. It means that applications once rejected because of price can now be re-evaluated. It also means that a number of new applications can now be brought under consideration.

Preparation

The preparation of phenolic premix materials requires both adequate mechanical mixing and sufficient heat for chemical advancement of the resin. This operation is done in a heated kneader or similar type mixer performing 3 major functions: it dry-blends the dry ingredients, mixes the resin and dry ingredients into a homogeneous mass, and advances the cure of the resin to a state suitable for molding. The dry ingredients (calcium carbonate, clay, wood flour, sisal, lubricant, and color) are added to a heated mixer and blended until a uniform mix is obtained. The liquid phenolic resin is then added and time of resin addition noted. Mixing is continued for a predetermined time to ensure satisfactory advancement of the resin. Approximately 10 min. prior to the predetermined dump-time, glass fibers, if included in the formulation, can be added. (Dump-time is predetermined and dependent upon the cure of the resin, mixing temperature, and formulation.) When dumped, the material is in a state suitable for molding. Depending upon the formulation utilized, the form of the premix can vary from fine hard granules to large hard lumps. This material has almost unlimited stability and no special packaging precautions are required.

A recipe for a typical premix compound is as follows:

Resin: Liquid phenolic	40.0%
Fillers: Wood flour	28.0%
"Silvacon" wood-bark derivative	9.0%
Calcium carbonate	5.0%
Reinforcements: Sisal	15.0%
Lubricant: Zinc stearate	1.0%
Color: Carbon black	1.0%
Neutralizer: Calcium hydroxide	1.0%

Resin

As is the case with standard phenolic molding materials, there are many different resins for specific applications. However, in all cases, the principal function of the resin in any molding material is to flow through and fill out the mold cavity and to bond the fillers and reinforcement. Liquid resins having low viscosities at elevated temperatures are necessary to obtain adequate wetting-out of the added components, but these resins must have high solids content, i.e., be low in diluents, so as to minimize the amount of volatiles to be removed. Low-solids resins require extended, and therefore uneconomical, mixing cycles. To allow for adequate mixing time and necessary control, resins with stroke cures of over 40 sec. are required.

The properties of a typical water-soluble, one-step premix resin[1] are as follows:

Reactive "solids" content, %	75.0
Viscosity, 25°C., cp.	200.0
Stroke cure, 150°C., sec.	55.0
Set time, 135°C., sec.	490.0
pH	7.6
Specific gravity	1.25

Phenolic materials prepared with this type of premix resin exhibit a normal shelf life of about 3 months; after this period they do not flow as well. However, even after 6 to 9 months on the shelf, the premixes are completely moldable at slightly higher pressures.

Fillers

Various mineral and cellulosic fillers such as clay, limestone, mica, asbestos, wood flour, and "Silvacon" are used in phenolic premix molding compounds.

Wood flour is the most widely used of all phenolic fillers because of low cost, low specific gravity, and excellent strength. Wood flour comes in various type woods and mesh ranges; white pine of approximately 100 mesh is usually preferred.

"Silvacon," a bark derivative

TABLE I: Typical premix compound data

Powder properties	*Value*	*A.S.T.M. Method*
Form of material	¼ in. lumps	—
Bulk factor	2.7–3.4	D-392
Molding temp., °F.	300–375	—
Molding pressure, p.s.i.	1500–2000	—
Storage life, mo.	3	—
Properties of molded material		
Specific gravity	1.38	D-792
Flexural strength, p.s.i.	8500	D-790
Flexural modulus, p.s.i.	0.8×10^6	D-790
Tensile strength, p.s.i.	5000	D-638
Tensile modulus, p.s.i.	0.9×10^6	D-638
Compressive strength, p.s.i.	19,000	D-695
Izod impact, ft.-lb./in. of notch	1.7	D-256
Heat distortion, °C.		D-648
at 66 p.s.i.	200	
at 264 p.s.i.	187	
Water absorption, %	1.8	D-570
Oil resistance (13 days immersed in SAE 10 Oil)	Unchanged	—
Hot-cold cycle (24 hr. at 175° F.–24 hr. at 40° F.)	No cracks	—

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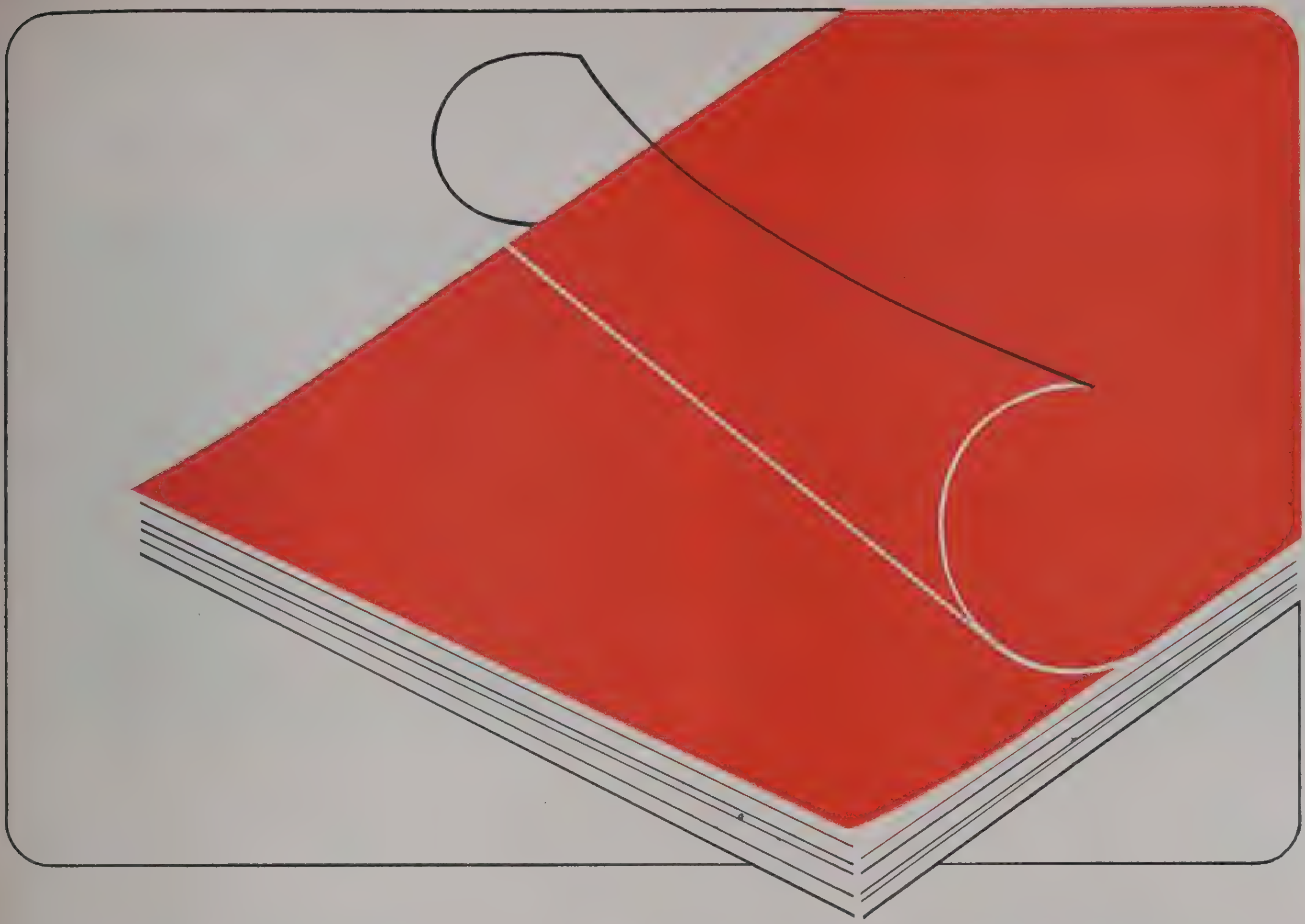
*Allied Chemical Corp., Plastics and Coal Chemicals Div., 40 Rector St., New York 6, N. Y.

[1] Plaskon resin, product of Plastics and Coal Chemicals Div., Allied Chemical Corp.



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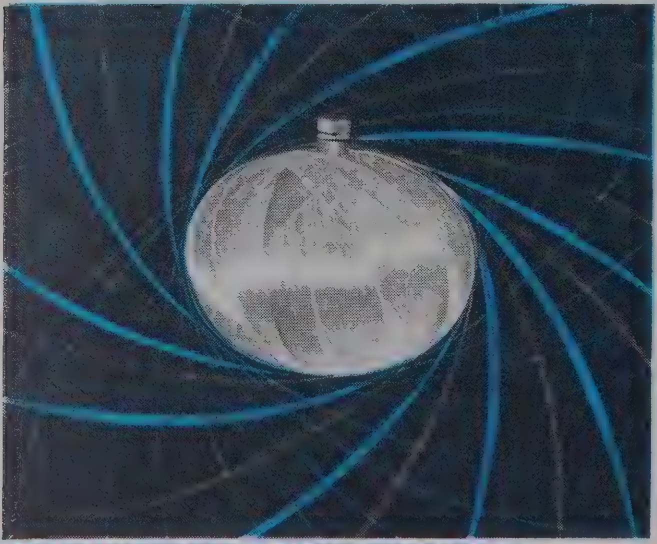

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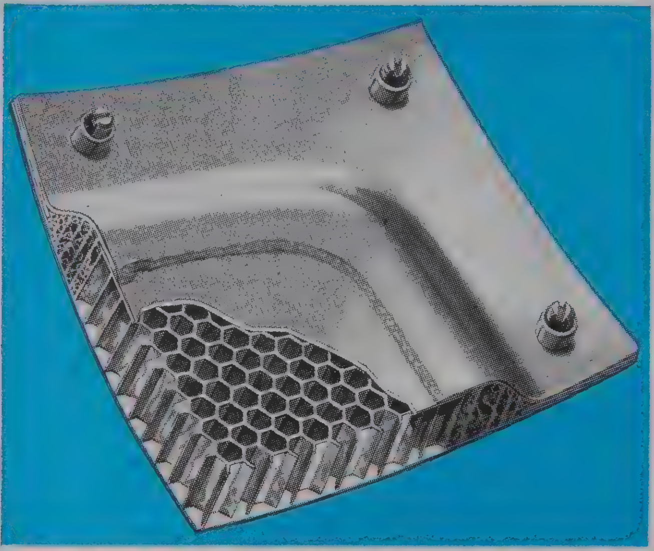

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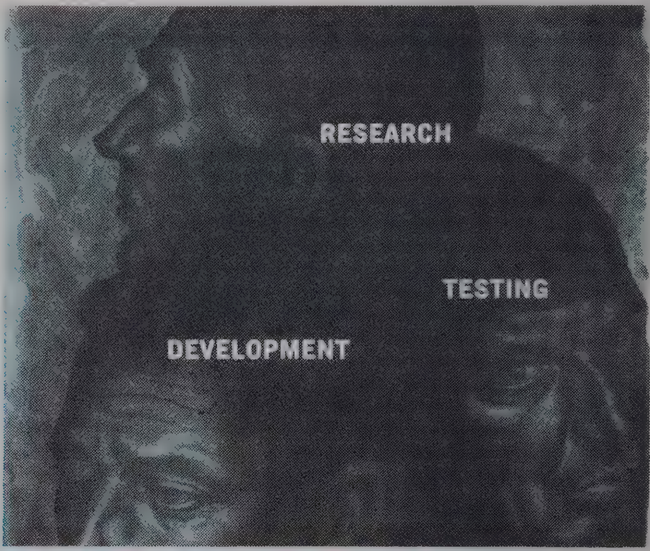

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containing natural resinous material, is used as an extender to reduce the resin content and hence reduce cost of the mix.

Limestone has a low oil-absorption value. Therefore, limestone-filled premix compounds require less resin. Since it is white, it also imparts improved surface finish and makes colors more brilliant.

Reinforcement

Chopped glass, sisal, and cotton fabric and flock are the most widely used reinforcing materials. Glass fiber, because of its high cost, is only used when exceptional strength is needed. Phenolic molding materials containing glass fiber require extra care and special handling because the bundles of glass filaments that make up chopped fiber disintegrate and lose their reinforcing ability if worked excessively.

Sisal fibers impart good impact strength. This material has a high affinity for water; thus, compounds requiring good water resistance should not be formulated with sisal. On a weight/cost basis, sisal delivers the highest impact strength of any material now on the market. Parts molded from sisal-filled compounds, however, have a characteristic orange-peel surface that precludes some applications.

Cotton fabric or flock materials impart good finish and good water resistance properties to the molded part. However, they impart only half the impact strength of sisal.

Lubricants, such as metallic stearates and low-molecular-weight polyethylene, are commonly used with phenolic premix materials to aid in processing and to assist the removal of the part from the mold.

Color: Generally, phenolics have poor color properties and will fade when exposed to light. Molding materials are limited in color to black, brown, and other dark (red and green) shades. Various dyes or pigments can be used with phenolics. While light colors can be molded, their limited durability usually makes them impractical.

Standard compression molding presses are satisfactory for phenolic premix materials. The basic molding procedure is to compress the material into the desired shape and hold it under pressure and heat (300 to 350° F.) until the chemical action which yields a hardened material takes place. Premix materials, like standard phenolics, require pressures in the range of 1000 to 3000 p.s.i.

Most phenolic molded parts usually do not require cooling jigs. Large parts with thin wall sections are, however, comparatively weak while hot and will distort or warp if not supported by a cooling jig.

The standard finishing and trimming operations used with standard phenolics are also used for premix materials, but premix materials filled with glass will require special handling because of their high abrasive action.

Sprayup systems

Newest tool for the reinforced plastics industry is sprayup, a method whereby catalyzed and promoted resin is simultaneously projected with continuous or chopped glass roving onto a mold surface.

A number of commercial systems available consist of dual-nozzle resin spray guns and glass choppers or continuous roving projectors. These units are mechanically linked and separately adjustable so that a predetermined proportion of glass and resin can be applied to the mold surface, with the individual glass filaments thoroughly and uniformly wetted with the resin.

In conventional hand layup of glass mat or cloth, the problem is to get enough catalyzed resin into the glass to coat the fibers completely and also avoid resin-starved areas. This problem is complicated by the time element: once the resin, catalyst, and promotor have been mixed, the "pot-life" of the mixture is extremely short. Hand impregnation of the glass must be done with small batches to avoid premature set-up of the mix, and the amount of resin that can be worked into the glass by hand is limited by the pot-life. High glass content is often desired to give adequate physical properties. But as the thickness of the glass layer is increased, the time

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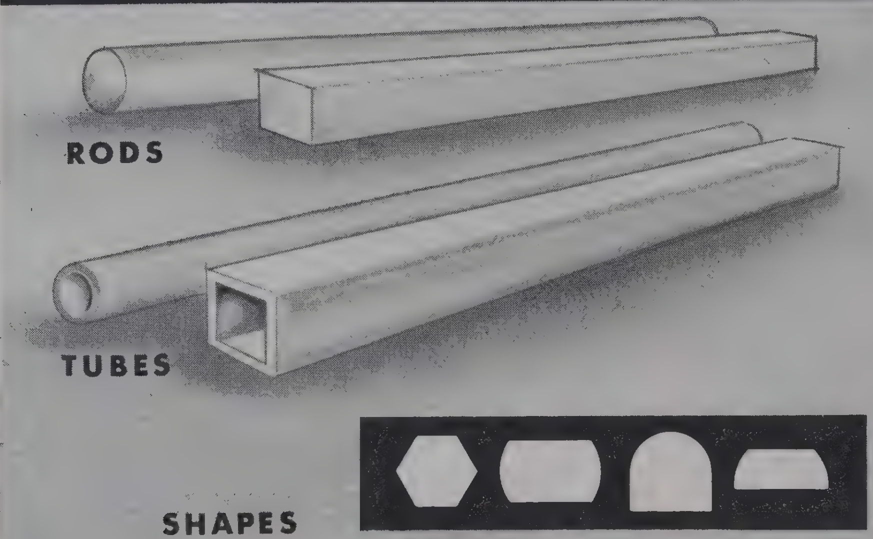

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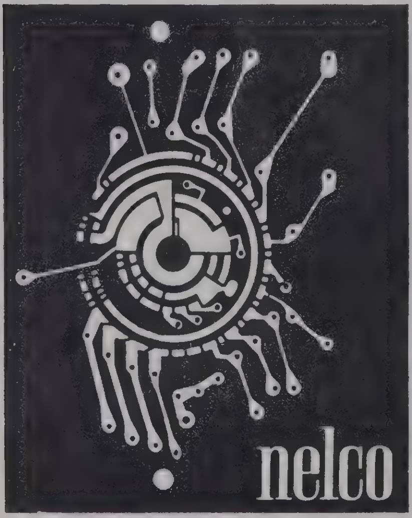

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element makes it more and more difficult to work in enough resin to wet the fibers and produce a void-free laminate.

Time element overcome

In the sprayup systems, the pot-life factor is virtually eliminated because the catalyzed resin and the promoted resin are kept in separate containers until an instant before they are combined and meet the glass. Separated, they remain workable for several days. Once combined, their gel time drops to minutes or even seconds. In sprayup, the final mixing does not take place until the resins are forced through the nozzles of the guns.

In some systems, the resin is projected as two separate streams, which meet in the air and become intimately mixed; in others, mixing takes place within a special head of the gun and the combined materials are projected from a single nozzle. In either case, the resin spray starts immediately to wet the glass and a laminate is built up, the uniformity of which depends only on the skill of the operator in controlling the motion of the combination gun.

After the laminate is laid down, only a simple rolling operation is necessary for compacting and eliminating air bubbles.

References

Consult Subject Index for additional information on molding reinforced plastics. See also Low-Pressure Laminating Resins Chart and Laminates Chart for information on properties and trade names. For sources, consult the Directory Index, p. 1078.

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Sandwiches

Part 2: Cores

The structural sandwich panel consists of three or more layers of material bonded together so they act as a unit. The thin, outer layers, or skins, are a dense, strong material designed to bear most of the load. Skins and facings were discussed in Part 1, p. 204; applications on p. 456.

The core is a softer, lighter, and weaker material. Its primary function is to stabilize the outer skin, preventing buckling under stress. It may also serve as thermal insulation.

And, of course, adhesives are also necessary to hold the components together. This article, Part 2, will cover cores and adhesives.

Cores

There are two basic forms of plastics core material: the expanded, or honeycomb type, and the rigid cellular or foam type.

Foamed plastics cores provide thermal insulation, resistance to humidity and many chemicals, good dielectric properties, and density that can be closely controlled in compounding. They may be either prefoamed or foamed-in-place.

Polystyrene foam is available in the form of prefoamed logs cut into slabs, boards, and simple tailored shapes and as expandable beads for foaming-in-place. The latter are particularly good where complex shapes are to be made. Polystyrene foam has adequate structural strength for most building applications and good resistance to water. Its relatively low heat-distortion point limits high-temperature applications. Unmodified styrene burns, but self-extinguishing varieties are now available.

A promising recent development is the combination of expandable styrene beads with epoxy resin. When these are mixed, the epoxy gives off heat as it cures, thereby causing the beads to expand at the same time that the epoxy bonds them firmly together; the result is a stronger, more rigid bond than is possible with the beads alone. If expansion takes place against the skin of a sandwich, the epoxy at the same time bonds to the skin and an outside source of heat is unnecessary.

Urethane foams, because of the wide variety of possible reactants, are quite versatile and can be given all degrees of rigidity. They provide good structural strength, low thermal conductivity, low water permeability, and excellent adhesion to many surfaces without bonding. Large-volume sections may be molded in relatively simple molds. However, they do require suitable (although simple) mixing equipment and proper precautions in the use of isocyanates, which themselves are toxic, although the finished foam product is not.

Phenolics are favored as a rigid core material from the standpoint of cost, but when made in high densities, they tend to be brittle and relatively weak. They can, however, be combined with honeycomb cores to take advantage of the best physical properties of each.

Other rigid plastics foams which can meet the requirements for structural sandwich panels at moderate densities include: cellulose acetate, polyethylene, polyvinyl chloride, silicone, urea formaldehyde, and epoxy.

Honeycomb cores: When kraft paper is impregnated with phenol formaldehyde resin and bonded together with strips of glue in a manner which allows the resulting material to be expanded much in the same way as paper Christmas bells, the type of sandwich core known as honeycomb results.

Depending upon the weight of the paper, the ratio of resin to paper, and the cell size, a material with a wide range of weight and strength properties is obtained. When bonded between facings of a structural sandwich, the honeycomb provides excellent lateral stability for the facings and prevents buckling under compressive loads which are either perpendicular to the facings or in the plane of the facings. The honeycomb also provides the necessary shear strength in a sandwich subjected to bending. If it is desirable to vent the core of the sandwich to the atmosphere, the individual cells of the honeycomb can easily be pierced during fabrication, before the honeycomb is expanded into its final form. This allows for breathing and for equalization of the pressure inside the panel with changes in temperature if this proves to be desirable.

If resin content is high enough, the resistance of the honeycomb to moisture is good. However, raising the resin content too high not only increases the cost but tends to make the honeycomb brittle.

The insulating value of honeycomb, alone, is not outstanding. If maximum insulation is required, the cells of the honeycomb can be filled with an insulating material, such as one of the various loose, granular materials, or one of the several types of foaming plastics.

Adhesives

Adhesives play a key role in the functioning of a sandwich by providing the essential bond between core and facing. The ideal adhesive must have high peel and shear strength with good resistance to impact; it must be free of any tendency to creep and able to accommodate itself to the changing dimensions of core and facings with changes in temperature or moisture content.

Condensed from sections appearing in "Building With Plastic Structural Sandwich Panels," a study prepared by Mass. Inst. of Tech., Dept. of Architecture, in assoc. with the Plastics Div., Monsanto Chemical Co.

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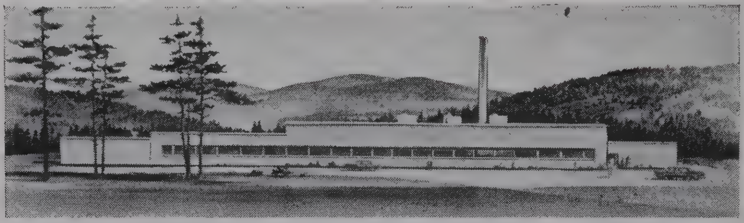

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CONTINENTAL-DIAMOND FIBRE

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HELPS YOU IMPROVE DESIGN
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HOW CDF SERVICE, RELIABILITY, AND RESEARCH HELP YOU IMPROVE DESIGN, SIMPLIFY PURCHASING, SPEED PRODUCTION

CDF SERVICE 95% of U. S. and Canadian industry lies within a local phone call of a CDF Sales Office. Four independent plants throughout the nation ensure deliveries as promised, as specified, and on time. Besides the sales offices listed on the back of this folder, there are expediting and sales-service offices at each plant.

CDF has extensive plastics-fabrication facilities which can be made "a part of your own production line," freeing your production personnel and equipment from this highly specialized job and insuring you against high reject rates and time consumption. Of course, CDF also manufactures its products in standard sheet, rod, and tube form for those users who prefer to fabricate their own plastics and fibre parts.

CDF RELIABILITY 85% of CDF products are sold to Military, Federal, NEMA, or customer specifications requiring close quality control over every step of manufacture. The CDF Specification Department at Newark, Delaware, will gladly work with you to set up realistic and adequate specifications that will provide you a satisfactory material for your needs—at minimum cost.

CDF RESEARCH 80% of CDF sales to the plastics and electronics industries are of products developed in the last seven years. The CDF research staff works daily with customers on new materials and processes. Some typical developments of the past few years are asbestos-reinforced phenolic laminates that withstand short-time heat exposures up to 3000° F., laminates of glass-supported duPont "Teflon" TFE fluorocarbon resin for electronics applications at 10,000 megacycles, and flame-retardant epoxy laminates.

CALL YOUR NEAREST CDF SALES OFFICE (listed on the back page of this folder) for help in the design stage, or for a recommendation based upon an existing print or problem.

CDF MAKES

Di-Clad printed-circuit laminates—see below
Dilecto laminated plastics—see page 2
Celoron molded products—see page 4
Products of Teflon*—see page 4
Diamond Vulcanized Fibre—see page 3
Vulcoid Resin-Impregnated Fibre—see page 3

DI-CLAD

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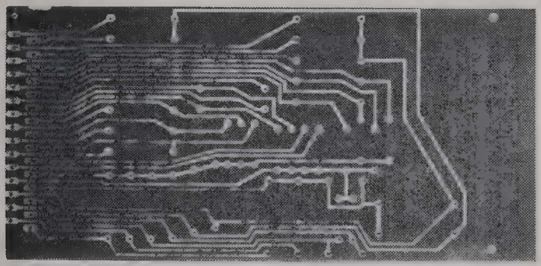
* DuPont Trade Mark



Grade Selection Chart

Reinforcement → Resins ↓	Glass Cloth High tensile, flexural and impact strength High continuous operating temperature Low moisture-absorption	Celluose Paper Low-cost Eastly fabricated High dielectric strength
Phenolic Resin low-cost general-purpose resin		Di-Clad 28 general-purpose XXXP type Di-Clad 2350 low-cost
Epoxy Resin high mechanical strength very high bond strength EFR grades flame-retardant	Di-Clad 28EV-2 general-purpose Di-Clad 28EFR flame-retardant	Di-Clad 31EFR flame-retardant XXXP type
Teflon Resin low loss at all frequencies low dielectric constant independent of frequency high service temperature limited by copper life only non-tracking	Di-Clad 112T general purpose Di-Clad 112TK controlled dielectric constant for microwave applications	

Other special grades are also available

Di-Clad Properties
1/16" Sheet, tested as received

Average Values

	Di-Clad 28	Di-Clad 2350	Di-Clad 28EV-2	Di-Clad 28EFR	Di-Clad 31EFR	Di-Clad 112T	Di-Clad 112TK
Insulation Resistance, (Megohms) 96 hours at 35° C & 90% RH (ASTM) D-257, Fig. 3	1,000,000	500	100,000	100,000	1,000,000	75,000	80,000
Dielectric Strength, vpm. perpendicular, short-time	900	800	600	550	650	700	700
Dielectric Constant, 1 mc.	3.6	4.5	4.8	4.8	4.0	2.6	2.5
Dissipation Factor, 1 mc.	.027	.040	.020	.009	.03	.0015	.0013
Loss Factor, 1 mc.	.10	.18	.096	.043	.12	.0039	.0032
Arc-Resistance, sec.	5	5	130	180	50	180	180
Flexural Strenth, psi.	18,000	27,000	70,000	70,000	23,000	13,000	12,000
Izod Impact Strength, ft.-lb/in. notch	.42	.80	11	18	.07	6.0	6.0
Copper Bond Strength, lb/in., G	8	8	11	10	10	6	6

DILECTO

LAMINATED SHEETS, RODS, AND TUBES

Dilecto laminates are made of a wide choice of thermosetting resins and reinforcements to produce materials having electrical, mechanical, and fabricating properties covering most insulation requirements.

Typical sheet grades are outlined below. Equivalent rod and tube grades are available in most categories. A large number of modifications of these basic grades can be supplied when required.

DILECTO GRADE SELECTION CHART

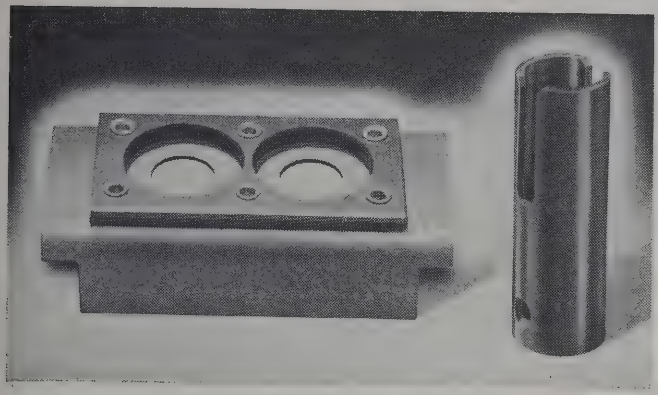
Reinforcements → **Resins ↓**	**Cellulose Paper**	**Cotton Cloth**	**Asbestos**	**Fiber Glass**	**Nylon Cloth**
	Low cost Excellent fabrication High dielectric strength	Higher strength Easy machining	High service temperature	Very high strength High service temperature	Tough High insulation resistance
Phenolic low cost general purpose	XXXP-28 excellent electrical properties moisture resistant good punching 2350 low cost electrical grade X-13 general purpose mechanical grade	C-813 general purpose mechanical C-1513 heavy weave mechanical C-313s fine weave mechanical L-400 very fine weave mechanical CE-800 general purpose electrical CE-300 fine weave electrical LE-13 very fine weave electrical	A-13 asbestos paper AA-13 asbestos cloth FA-72 asbestos mat	GB28D general purpose GB261D staple cloth for interply adhesive	MEC-5 general purpose MEC-423 post forming
Epoxy very high strength low moisture absorption good arc resistance	XXXP-31EFR flame retardant XXXP type			GB-28EV-2 general purpose GB-28EFR flame retardant high hot strength	
Teflon loss properties independent of frequency widest service frequency range low dielectric constant excellent arc resistance high service temperature				GB-112T general purpose GB-112TK controlled dielectric constant GB-108T fine weave	
Silicone high service temperature low moisture absorption good arc resistance				GB-125 general purpose GB-895 low cost	
Melamine high arc resistance high strength very hard		MC general purpose		GB-28M general purpose	
Polyester low cost low loss properties				GMPE general purpose GMP-100FR flame retardant	

Dilecto Properties

	GMPE	GB-28M	GB-125	GB-112TK	GB-28EV2	GB-261D	AA-13	M C	LE-13	CE-800	C-813	XXXP-31EFR	2350	XXXP-28
Insulation Resistance, Meghoms	500	50	10,000	1,000,000	100,000	2,000		10	100	100	25	1,000,000	500	1,000,000
Dielectric Strength, Perp., vpm.	350	500	400	700	600	450	75	200	550	500	450	650	650	800
Dissipation Factor, 1 mc.	.020	.012	.002	.0008	.020	.01			.05	.05	.06	.03	.04	.03
Dielectric Constant, 1 mc.	5.0	7.2	3.4	2.5	4.8	4.2			4.8	5.2	6.0	4.0	4.5	3.6
Arc-Resistance, sec.	125	190	250	180	130	5	5	125	5	5	5	5	5	5
Flexural Strength, psi	28,000	46,000	28,000	13,000	70,000	22,000	19,000	23,000	18,000	18,000	20,000	24,000	25,000	18,000
Izod Impact Strength, ft-lb per in. notch	15	10	9	6	12	7	5	2	2	2	3	0.7	0.8	0.5
Moisture Absorption, %, 1/16", 24 hrs.	0.5	2.0	0.2	.03	0.2	1.5	1.4	2.0	1.4	1.8	2.0	0.3	1.9	0.6
Maximum Continuous Service Temp., °C.	150	150	200	250	150	135	155	120	105	105	105	110	105	110

CONTINENTAL DIAMOND FIBRE

VULCANIZED FIBRE — FABRICATED AND FORMED



GOOD EXAMPLES of Diamond Fibre formed and machined by CDF. Left—An insulating barrier made from three pieces of fibre, punched and formed. Fibre tubing is even used for rivets. Right—A fibre tube which has been smooth-sawed to length, punched twice and countersunk. CDF can handle the entire job for you, do it faster and at low cost. This includes selecting and testing the proper grade of fibre, machining, inspection, and assembling if needed.

If your job is to select a general-purpose insulating material that is low cost, useful for both electrical and mechanical applications, easy to machine and form, consider the advantages of a unique old-timer—CDF's Diamond Vulcanized Fibre.

GOOD ELECTRICALLY. Although given a modest insulation rating for resistance to heat (A.I.E.E. Class A with a temperature limit of 221° F.), Diamond Fibre is often used because of its excellent arc-resistance and good dielectric strength. It also has desirable deionizing properties and low heat-conductivity. Fibre can be combined or surrounded with moisture-resistant laminated plastic.

MANY GRADES AND FORMS. Diamond Fibre sheet and roll grades include Bone, Commercial, and Electrical Insulation (fish paper) NEMA grades. Fibre tubing is normally made only in Bone grade, with rods available in both Bone and Commercial grades. The chart shown outlines the major characteristics of these grades.

CDF BONE FIBRE	Hard, stiffest grade. High density. Resists wear, abrasion, has high compressive strength. Good dielectric strength when dry. Super machining qualities. Not recommended for bending.
CDF COMMERCIAL INSULATION	Mechanical and electrical grade. Medium density. Tough, pliable. Good mechanical properties. Fair dielectric strength, normally, high when dry. Can be bent, punched, and formed.
CDF DIAMOND INSULATION	Electrical insulation "fish paper" grade. Unusually free from foreign matter. Withstands extreme bending and forming without cracking. High dielectric strength, except under high humidity.

TOUGH, RESILIENT, STRONG. How long has it been since you examined the unique properties and wide range of CDF fibre grades? Vulcanized Fibre is arc-resistant, mechanically strong, non-corroding, half the weight of aluminum. Repeated moistening and drying in forming insignificantly alters the nature, structure, or quality of the fibre.

MECHANICAL PROPERTIES OF DIAMOND VULCANIZED FIBRE

Property	Sheet thickness, tube wall or rod diameter	SHEETS				TUBES	RODS	
		Bone		Commercial			Bone	Commercial
		CW	LW	CW	LW			
Tensile Strength	Up to 1/8"	6500	8500	6000	8000	6500	8500	8000
	Over 1/8 to ½	6000	8000	5500	7500	6500	8000	7500
	Over ½	....	....	5000	7000	6500	....	7000
Flexural Strength	Up to ½"	13,000	15,000	12,000	14,000		15,000	14,000
	Over ½	....	....	11,000	13,000		....	13,000
Compressive & Axial Strengths	Up to 1/8"					10,000		
	Over 1/8 to 5/16					9000		
	All thicknesses or diameters	30,000		20,000			8000	6000

VULCOID — RESIN-IMPREGNATED FIBRE

Only CDF supplies Vulcoid, in sheets, tubes, rods, and fabricated parts. Made from Diamond Vulcanized Fibre that has been uniformly impregnated with a special resin, Vulcoid is a material approved and identified by the Underwriters' Laboratories as Class A Insulation. Natural greenish-tan in color, it is economical, easy to machine and punch. Property-wise, Vulcoid is an intermediate grade between Commercial Fibre and XX phenolic Dielecto.

USES: (requiring arc-resistance and mechanical strength)—contact and connector panels, knife-switch arms and guides, arc-deflector spacer bushings; (requiring dielectric strength and moisture resistance)—electrical fixture insulation, wiring devices, plugs, receptacles; (requiring moisture- and arc-resistance)—motor and transformer lead bushings and terminal blocks. Write for folder V-55, and test samples.

TEFLON

TEFLON TFE resin performs satisfactorily at frequencies up to 10,000 megacycles, at temperatures up to 500° F, and at all humidities. It resists the heat of a soldering iron.

Where mechanical properties are critical, glass-cloth-reinforced Teflon is used. Its flexural strength and modulus and resistance to creep and cold flow are much better than pure Teflon, but its dielectric constant, dissipation factor, and moisture absorption are increased.

SKIVED TAPE Pure Teflon tape having high dielectric strength and high elongation. Used as a wire and cable wrap and as electronic insulation. Widths up to 18 inches, thickness of 0.002 inch to 0.100 inch.

ST—X : best electrical grade
ST—1 : general-purpose grade
ST—2 : low-cost grade (reprocessed)

SUPPORTED TAPES Teflon coated on woven glass cloth. High tensile strength and excellent resistance to cold flow and cut-through. Used as wire and coil wrap, and slot lining. Widths up to 38".

General-Purpose Grades	*Thickness*
GB-108T	0.004 inches
GB-112T	0.005
GB-116T	0.006
GB-128T	0.010
GB-141T	0.015
Low-Cost Grades	
GB-108TL	0.003
GB-116TL	0.005
GB-128TL	0.009

SPAGHETTI TUBING Thin-walled flexible tubing is available in 10 colors and in all AWG sizes and in many larger sizes up to 2 inches O.D.

Grade: PETU—1

RAM-EXTRUDED ROD AND TUBE Rods and tubes with minimum sections of ⅛" are available in sizes up to 1½" O.D.

FORM	*GRADE*
Rod	RER—1
Tube	RETU—1

UNFUSED TAPE Extruded unfused tape that will seal to itself when fused at 700° F is used for wire wrapping and other applications requiring a continuous seal of pure Teflon. Ten colors are available in widths up to 6" and thickness of 0.003" to 0.010".

Grade: ET—1

MOLDED INDUSTRIAL PLASTICS

CELORON

CELORON—MOLDED INDUSTRIAL PLASTICS

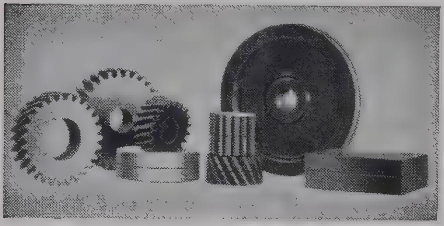
Celoron of laminated or molded-macerated cotton fabric-base construction is used extensively for industrial and automotive timing gears. Celoron molded-macerated cotton fabric or paper is used for many mechanical and structural electrical applications. Celoron is unaffected by rapid temperature changes, may be used continuously at 225 to 250° F. It has high impact strength, excellent resistance to heat, oil, and water, many chemicals. Either laminated or molded Celoron is easily machined.

SHEETS

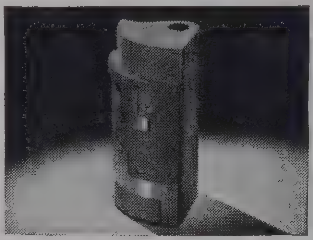
From laminated stock, fabric-based phenolic-impregnated Celoron can be furnished in sheets, cut pieces, blanks, and rings machined from sheet stock. For gear applications (idler and spur gears, cams), it is normally identified by two black lines. See Dilecto C grades for mechanical applications requiring toughness plus impact strength.

MOLDED

Celoron can be molded to close tolerances for both mechanical and electrical applications. Rugged, dimensionally stable, readily machined, Celoron is a dependable material; remember CDF has both the men and the equipment to handle "big-run" molding requirements.
Celoron Colors: Golden mottled brown or black.



GEARS
These gears, pulleys and discs are all Celoron which finds wide usage in textile and printing machinery. Build silence into your product with Celoron gears. Write for Celoron catalog with horsepower ratings.



INSULATION
This diesel contact controller drum assembly uses two C-D-F products: Celoron drum body, drilled and broached; Diamond Vulcanized Fibre between fingers of the brass contact plate.

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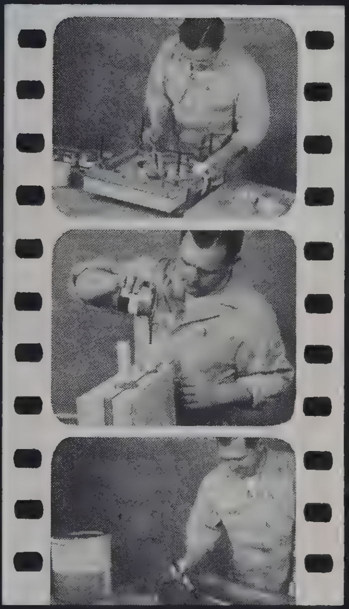

DON'T MISS THIS NEW SOUND-COLOR MOVIE! "Plastics Tooling and Patternmaking with EPOXICAL Resins" shows how ULTRACAL Gypsum Cement molds are made to produce plastic foundry patterns. See plastic match plates, core boxes, and cope and drag equipment being made—quickly, with improved accuracy, at reduced costs! See how EPOXICAL can help you! For FREE showing—mail coupon!

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I would like to see your latest 16mm. color movie, "Plastics Tooling and Patternmaking with EPOXICAL Resins." Please send me complete information so definite arrangements can be made for a FREE showing—**soon.**

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REINFORCED PLASTICS DEVELOPED TO ENDURE THE FIERY REALM OF THE ROCKET

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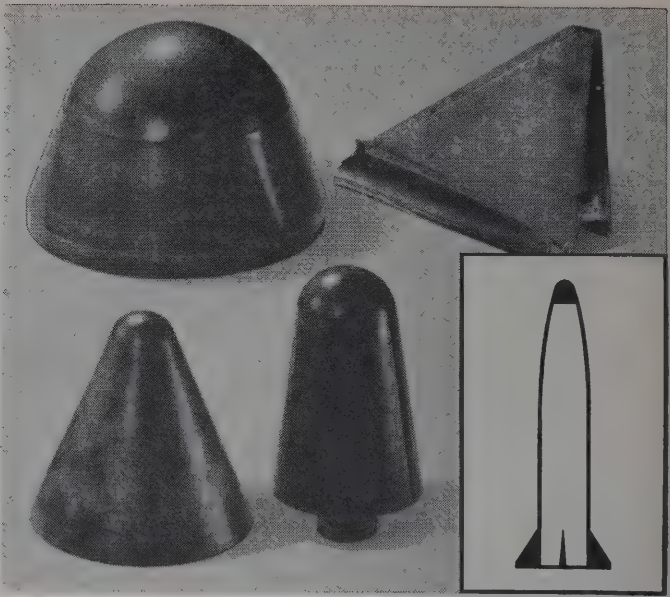
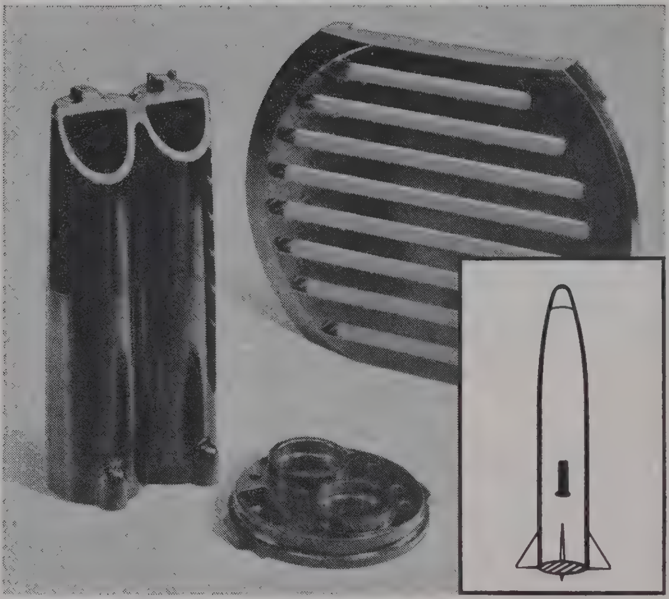
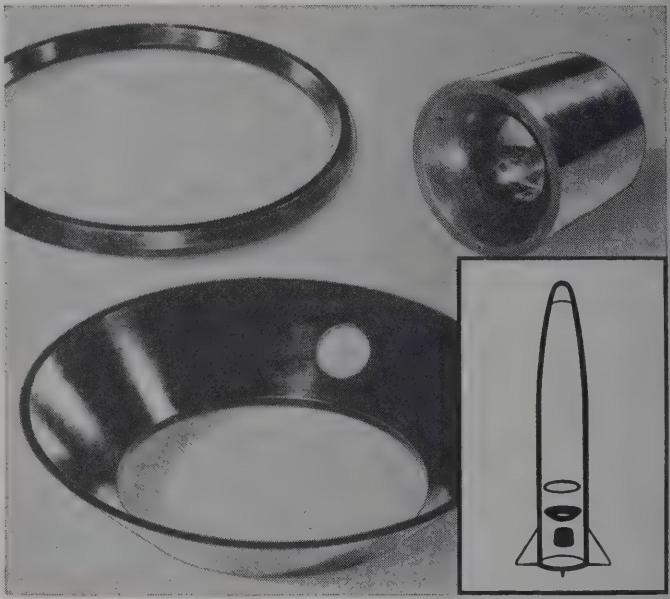
both structural and aerodynamic



Smooth, strong rocket fin and nose cones made of R/M Pyrotex resist aerodynamic heating; have low, uniform ablation rate. The fin shown was subjected to tests at Mach 7.



High heat resistance makes R/M Pyrotex the ideal material for rocket sliver traps, igniter tubes, and tube covers. Pyrotex parts exhibit high strength retention after repeated exposure to 5000-6000°F.



Good insulating properties have led to the use of R/M Pyrotex for rocket throats, aft insulators, and grain seat rings. Pyrotex can be molded or laminated into a wide variety of shapes.

Are you looking for a material that will withstand the elevated temperatures generated by missiles and rockets—internally from burning propellants, externally from aerodynamic heating? Must this material have good insulation and thermal properties, chemical and water resistance, and take a smooth finish? If so, R/M Pyrotex reinforced plastics may be the solution to your problem.

The many outstanding thermal and structural features of R/M Pyrotex have led to its use on almost every U.S. missile. It has been fabricated into parts such as nose cones, fins, nozzle liners, exit cones, and motor casing insulation. Its exceptionally good dimensional stability makes possible mass production to precision standards. And it is low in cost.

THE COMPLETE LINE OF R/M REINFORCED PLASTICS

If your design demands all of the following features, find out more about R/M Pyrotex (felts, mats, papers and molding compounds):

- Heat and flame resistance up to 10,000°F or more
- Chemical and water resistance
- Relatively isotropic
- High modulus of elasticity from low to high temperatures
- High strength from low to high temperatures
- Improved surface of end items
- Exceptionally good dimensional stability
- Little or no surface crazing
- Good insulation and thermal properties
- Low cost
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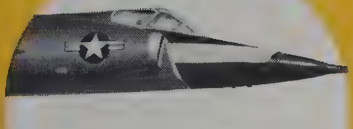

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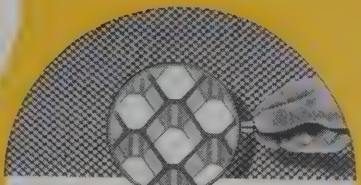

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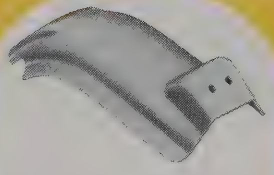

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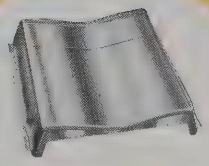

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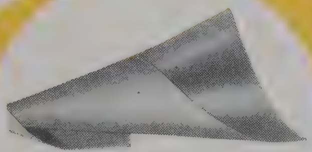

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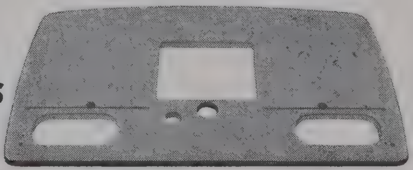

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COLORING REINFORCED PLASTICS

BY JAMES E. SIMPSON*

The large and growing variety of products molded of reinforced plastics has encouraged the development of specialized colors and techniques for use with these materials. The choice of colors and coloring methods can be an important factor in producing a quality product. In addition to the desired shade, such properties as light and heat stability and other physical properties of the pigments used should be considered.

Paste Colors—The most widely used method of coloring polyester and epoxy resins for reinforced plastics is by the use of paste colors. These colors are highly concentrated pastes or "dispersions" of pigments ground into a vehicle or carrier.

In use, the paste color concentrate is simply mixed into the uncolored resin by the molder. This method provides fast, even dispersion. With the use of quality controlled color pastes, it can simplify the production of uniformly colored products.

Ferro Paste Colors combine maximum pigment concentration with specially developed vehicles that are compatible and will react with the resins. These vehicles exhibit no plasticizing effect on the laminate and provide good shelf life stability.

For fast service and the economy of mass production, Ferro stocks a group of primary colors which can be combined to produce any shade desired. By purchasing these colors from stock and blending them in the plant for special color matches, many molders have reduced their color inventories, saved on waste and speeded up delivery of rush orders.

Color charts and complete technical data on Ferro Paste Colors for Polyester Resins and Ferro Paste Colors for Epoxy Resins are available on request.

Gel Coats—For hand lay-up production many molders are using Gel Coats. These thin, opaque colored coatings effectively hide the fiber glass mat and eliminate the need for coloring the complete laminate. They give the finished product a smooth, abrasion resistant surface that is chemically bonded to the laminate for long service.

Ferro Color Gel Coats are available in a wide selection of shades. Write today for literature and color chart.

Parting Films—To provide a smooth finished surface and to assure easy removal of the reinforced plastic part from the mold in hand lay-up operations, parting films are used. Ferro has developed a liquid parting film that is easy to apply and offers many special advantages. Complete information available on request.

Can we help you? Our color laboratory facilities are available to work with you on any problem or project you may have involving plastic colors. For information on any of the products mentioned above, please write Ferro Corporation, 4150 East 56th Street, Cleveland 5, Ohio, or 5309 South District Boulevard, Los Angeles 22, California.

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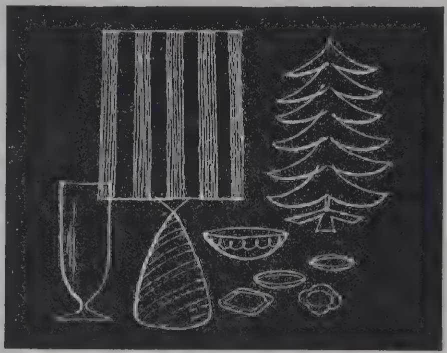
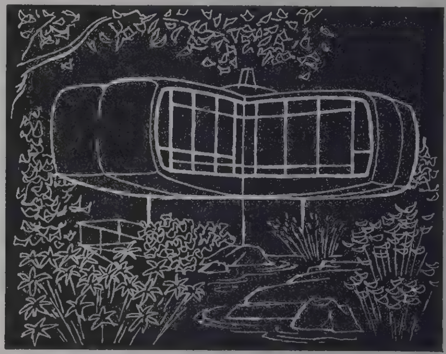
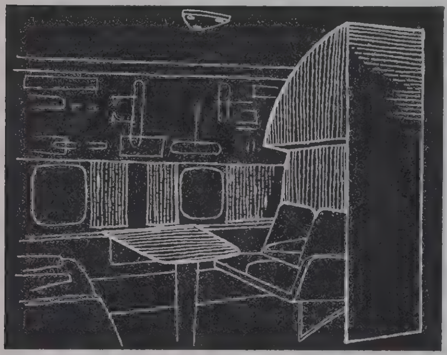
...IN BOATS – (meets Buships spec. MIL-H-21040) More than 50 U.S. and foreign boat manufacturers are using *Aircomb* for hull reinforcement, decks, partitions, seats, and topside structures. Bumpers of *Aircomb* are also being employed as shock-absorbing cushions in special marine launching operations.



...IN SPECIALTIES – Hundreds of thousands of pounds of unimpregnated Douglas honeycomb are being sold yearly to specialty manufacturers. Now available in a variety of colors, it is being used for sport hats, lamp shades, flower vases, miniature Christmas trees, coasters, and in hundreds of other interesting ways.

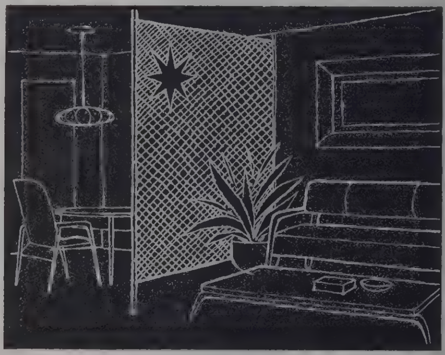


...IN MODERN BUILDINGS – *Aircomb* is a primary structural element in the famous "Monsanto House of the Future" now on display in Disneyland, California. It is being used in many new buildings for both exterior and interior applications like curtain walls, partitions, ceilings, floors, decorative panels, etc.



...IN AIRCRAFT – *Aircomb* is widely used in modern airliners like the Douglas DC-8 jetliner for tables, partitions, shelves, cabinets and for exterior access doors. Used for aircraft tooling faced with glass laminates, it is less affected dimensionally by moisture or temperature changes than any other material and can hold extremely close tolerances.

...IN MILITARY APPLICATIONS – Faced with glass laminates, *Aircomb* roofs for electronic and radar trailers are capable of bearing a distributed load of up to *1000 lbs.* per square foot. Treated acoustically in walls, it is superior to all other known materials for sound insulation. *Aircomb* is also being used in ground support equipment of all types.



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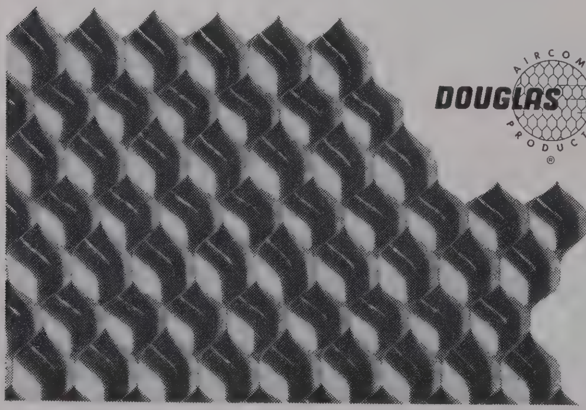

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TECHNICAL DATA

Foamed Plastics Chart 513

Adhesives Chart 516

Coatings Chart 524

Films Chart 532

Low-Pressure Laminating Resins Chart 537

Laminates Chart 547

Burning Chart 552

Fibers Chart 554

Plasticizers Chart 560

TYPE OF MATERIAL	URETHANE (POLYURETHANE; ISOCYANATE)								
	Open cell (flexible)	*Open cell; foam-in-place (flexible)*	*Open and closed cell; rigid*			*Open and closed cell; rigid; foamed in place*			
Forms available	Slab, sheets, blocks, custom shapes	2 and 3 package system for mixing on job	Custom made shapes			2 and 3 package system for mixing on job			
Standard sizes	Max. width: 80"; max. length: 120 ft.; thickness: 1/16 - 8"	–	–			–			
Density, lb./cu. ft.	1.5-4	2-20	1.5-3	4-8	9-12	13-18	19-25	26-40	41-70
Thermal conductivity, B.t.u./sq. ft./hr./°F./in.									
Blown with carbon dioxide	0.25 at 2 lb./cu. ft.	0.25 at 2 lb./cu. ft.	0.21-0.23 at 2 lb./cu. ft.	0.21 at 2 lb./cu. ft.	0.26-0.28	0.28-0.31	0.31-0.33	–	–
Blown with fluorinated hydrocarbon	0.12 at 2 lb./cu. ft.	–	0.11-0.14 at 2 lb./cu. ft.	–	–	–	–	–	–
Tensile strength, p.s.i.	18-50	13-150	8-50	75-225	250-325	375-500	525-800	800-3000	3000-8000
Compressive strength, p.s.i.	0.2-1.0 (at 25%)	0.5-1.5 (at 25%)	7-30	50-225	250-400	425-800	900-1200 +	1300-5000	5000-15000
Impact strength, ft.-lb./in.	–	–	–	–	–	0.32	–	0.45	0.45
Burning rate	Self-extinguishing (when specially compounded)				Self-extinguishing (when specially compounded)				
Max. service temp., °F.	Dry 260-275 Wet 212	260-275 212	Continuous 200-250	Continuous 250-350	Continuous 250-350	Continuous 250-350	Continuous 250-350	Continuous 300-400	Continuous 300-400
Elongation, %	150-500	200-500	–	–	–	–	–	–	–
Coefficient of linear expansion, in./in./°F.	–	–	1.4×10^{-5}	2.6×10^{-5}	3.5×10^{-5}	5.0×10^{-5}	–	4.0×10^{-5}	4.0×10^{-5}
Water absorption, % by volume	–	–	4.0 at 2 lb./cu. ft.	1.8	0.8	0.4	0.2	–	–
Dielectric constant	1.1	1.1	1.05	1.10	1.2	1.3	1.4	1.5	–
Loss tangent	0.5×10^{-3}	0.5×10^{-3}	0	0	0.5×10^{-3}	2.0×10^{-3}	3.0×10^{-3}	4.0×10^{-3}	–
Trade designations of this type of foam and foaming compounds	**OPEN AND CLOSED CELL FOAM** Airborne (74), Burkart (7), Curifoam (15), Cush-N-Foam Polyester (41), Eccofoam S and SH (24), Flexifoam (54), Foamex E (26), Fomrez (79), Insulfoam (62), Isoaire (23), Isofoam PE-2 (43), Nafil (11), Nopcofoam (53), Pelron (56), Pliofoam SL (35), Polyfoam (32), Polylite (59), Reynofoam (60), Selectrofoam (57), Sheller-Tex (67), Stafoam (1), Stafoam (17), Stanfoam (68), Unifoam (8), Vibrafoam (76)				**FOAMED IN PLACE** Cyofoam (3), Eccofoam FP and FPH (24), Fomrez (79), Genfoam (31), Isofoam (43), Loven (46), Mondur (50), Nafil (11), Nopco Lockfoam (53), Pelron (56), Polylite (59), Polyrubber (1), Reynofoam (60), Scotchfoam (49), Selectrofoam (57), Stafoam Lockfoam (1), Stafoam (17), Stanfoam (68), Urefoam (3), Vibrathane (52)				
Manufacturers of this type of foam and foaming compounds (see list on p. 515 for key to numbers)	1, 2, 6, 7, 8, 9, 11, 15, 17, 21, 22, 23, 24, 26, 32, 34, 35, 38, 40, 41, 47, 53, 54, 56, 57, 59, 60, 62, 66, 68, 73, 74, 76, 79				3, 9, 11, 17, 24, 40, 43, 46, 49, 50, 52, 53, 56, 59, 60, 68, 73, 79				

TYPE OF MATERIAL	POLYVINYL CHLORIDE FOAMS						
	OPEN CELL			CLOSED CELL			
Forms available	Flat stock in sheets and rolls Cored cushions and other molded shapes	**Resistance ratings**		Forms available	Sheets and molded shapes	**Resistance ratings**	
		Strong acids	E†			Strong acids	E
		Strong alkalies	E†			Strong alkalies	E
Standard sizes	1/16" to 5" thick; 24" to 54" wide	Greases and oils	G†	Standard sizes	36" × 44", 1/16" to 2" thick	Greases and oils	G
		Organic solvents	P to E†			Organic solvents	P to E
Density, lb./cu. ft.	3.5 and up	Water	E	Density, lb./cu. ft.	4 to 25	Water	E
Heat sealability	Excellent	High relative humidity	E	Heat sealability	–	High relative humidity	E
Tensile strength, p.s.i.	10 to 200	Sunlight	G	Tensile strength, p.s.i.	–	Sunlight	G
Elongation, %	75 to 300	Resistance to heat, °F.	150 to 225•	Elongation, %	–	Resistance to heat, °F.	150 to 225•
Flammability	Self-extinguishing			Flammability	Self-extinguishing		
Indentation load deflection* (lb./50 sq. in. at 25% def.)	3 to 500	Resistance to cold, °F.	Stiffens at +20 to –40•	Indentation load deflection* (lb./50 sq. in. at 25% def.)	–	Resistance to cold, °F.	Stiffens at +20 to –40•
Air oven aging, 22 hr. at 212°F.* (change from orig. ind. load def.), %	±20	Trade designations of this type of foam and foaming compounds	Aer-O-Buoy (63), Bolta Foam (30), Crestfoam (14), B.F.Goodrich PVC (33), U.S. (76), Vin-So-Lite (28), Vinylaire (23), Vinacel (35), Vinylfoam (75)	Air oven aging, 22 hr. at 212°F.* (change from orig. ind. load def.), %	–	Trade designations of this type of foam and foaming compounds	Aer-O-Buoy (63), Crestfoam (14), Ensolite (76), B.F.Goodrich PVC (33), Rubatex (36), Vin-So-Lite (28),
Compression set, 22 hr. at 158°F.* (max. based on original height), %	15			Compression set, 22 hr. at 158°F.* (max. based on original height), %	–		
Dynamic flexing—250,000 cycles* (max. set based on original height), %	10	Manufacturers of this type of foam and foaming compounds (see list on p. 515 for key to numbers)	6, 10, 14, 23, 25, 28, 30, 32, 34, 35, 47, 48, 51, 58, 60, 63, 72, 76	Dynamic flexing—250,000 cycles* (max. set based on original height), %	–	Manufacturers of this type of foam and foaming compounds (see list on page 515 for key to numbers)	10, 14, 28, 34, 36, 58, 63, 76
Water absorption, %	–			Water absorption, %	5 (max.)		

*SPI Tentative Specifications and Methods of Test for Vinyl Foams.

†Resistance decreases as plasticizer is increased.

•These compositions are the thermoplastic materials that gradually become softer as the temperature increases. The maximum and minimum service temperature will depend on formula of material, design of part, and service conditions.

TYPE OF MATERIAL	CELLULOSE ACETATE	PHENOLIC				UREA-FORMAL-DEHYDE	POLYSTYRENE					
Forms available	Boards and rods (rigid closed cell foam)	Liquid resin for foaming in place				Block and shred	Sheets or shapes molded from expandable beads			Homogeneous boards, planks and logs		
Standard sizes	Boards: 1" × 4"; ¾" × 6"; ½" × 8"; any length Rods: 2¼"; any length	–				Block: 20½" × 10½" × 4½"	–			Boards: 12", 16", and 24" widths; 1"–4" thickness 8' and 9' lengths Planks: 5" × 15" × 9' 7" × 20" × 9' 8" × 16" × 9' Logs: 25" × 33" × 6' or 9'		
Density, lb./cu. ft.	6-8	1/3-1½	2-5	7-10	10-22	0.8-1.2	1	2	5	1.8	3.0	4.5
Thermal conductivity, B.t.u./sq. ft./hr./°F./in.	0.31	0.24-0.28				0.18-0.21	0.26 at 70°F. mean temp.	0.24	0.250	0.25 at 40°F. mean temperature		
Tensile strength, p.s.i.	170	–	4-35	35-75	50-200	Poor	33	54	121	55	105	180
Compressive strength, p.s.i.	125	0.8-5	9-31	45-130	150-1100	200	14	29	115	16-32	50-80	120-140
Impact strength, Ft.-lb./in.	0.12	–	–	–		Poor	0.14	0.21	0.20	–	–	–
Burning rate, in./min.	4.5	Self-extinguishing				–	4-5 (can be made SE)			Styrofoam 33: self-extinguishing Styrofoam 22: non-self-extinguishing Styrocell: self-extinguishing Styrocell: non self-extinguishing		
Maximum service temperature, °F.	350	Continuous 300				120	175			155-175		
Coefficient of linear expansion, 10^{-5} in./in./°F.	2.5	–	–	–		–	4			3-4		
Moisture absorption, % by wt.	100% R.H.: 13-17 50% R.H.: 1.9-2.5	–	100% R.H. = 13-51 50% R.H. = 1-4	100% R.H. = 10-15 50% R.H. = 1-5		–	Nil			Nil		
Water vapor transmission, g./hr./sq. ft./in./cm. Hg	–	–	–	–		–	2.0			1.5-3		
Dielectric constant	1.12	–	–	1.19-1.20		–	< 1.05 at $10^2 - 10^6$ cycles			< 1.05 at $10^2 - 10^8$ cy./sec.		
Dissipation factor	–	–	–	0.028-0.031		–	< 0.0005 at $10^2 – 10^6$ cycles			< 0.0002 at $10^2 - 10^8$ cy./sec.		
Trade designations of this type of foam and foaming compounds	CCA (70), Strux (70)	Corfoam (61), Eccofoam GL (24), Kaston (58), Lebec (45), Marblette (48)				Colfoam (13)	Dow Pelaspan 8 (19), Dylite and Dylite F-40 (44), Styrocell (71)			Dermafoam (29), Eccofoam and Eccofoam PS (24), Puffoam (29), Scotbord (19), Spherofoam (65), Styrocell (71), Styrofoam (19), Styropor (4)		
Manufacturers of this type of foam and foaming compounds (see list on p. 515 for key to numbers)	70	24, 45, 48, 58, 61, 78				13	19, 44, 71			4, 19, 24, 29, 65, 71		

TYPE OF MATERIAL	POLYVINYL CHLORIDE *Plastisol (containing blowing agent)*	SILICONE			EPOXY *(Prefoamed Blocks)*	RUBBERS			
						NATURAL RUBBER	NEOPRENE	BUTADIENE-STYRENE (GR-S)	BUTADIENE-ACRYLONITRILE
Forms available	Liquid or paste	Powder			Blocks	Sheets, rolls, or molded shapes	Sheets	Boards	Sheets
Standard sizes	Foamed in place 3-30' at 310-400°F. closed or open cell	Foamed in place at 320°F. Cell size less than 0.08 in.			up to 1' × 2' × 6'	40"×120"; 1/8" to 1" thick; ¼ to 2" (sheets & rolls); 1" to 7" (molded shapes)	36" × 36" and 40" × 120"; 1/8" to 1" thick	36" × 36"; 1/2" to 2" thick	36" × 36"; 1/8" to 1" thick
Density, lb./cu. ft.	12-26	12	14	16	5-20	3.5-20	10-30	4.5	10-25
Thermal conductivity, B.t.u./sq.ft./hr./°F./in.	0.36	0.3	0.3	0.3	0.25-0.30	0.25-0.30	0.25-0.35	0.21	0.25-0.30
Tensile strength, p.s.i.	250-1200	–	–	–	5.6 lb. : 51; 17.7 lb. : 490	5-30	20-100	80	40
Compressive strength, p.s.i.	–	100	200	325	5.6 lb. : 62; 17.7 lb. : 950	–	–	40 and up	–
Impact strength, ft.-lb./in.	–	–	–	–	–	–	–	4-11	–
Burning rate, in./min.	Self-extinguishing	Nonflammable			Can be made SE	–	–	–	–
Maximum service temperature, °F.	150	700			300	160	180	160	210
Trade designations of this type of foam and foaming compounds	Chem-O-Sol (12), Dennis (18), Foamosol (77), Parcloid (55), Reynofoam (60), Stanley (69), Sterilkote (5), Vynafoam (42), Wilflex (27)	Dow Corning (20), Stanfoam (68)			DuRafoam (16), Eccofoam HiK 625D (24), Maraset (48)	Airfoam (35), C-Foam (1), Foamex (26), Rubatex (36), Texfoam (34)	Foamex (26), B.F. Goodrich (34), Rubatex (36)	Airfoam (35), Cell-tite (34), Foamex (26), Rubatex (36)	Cell-tite (34), Rubatex (36)
Manufacturers of this type of foam and foaming compounds (see list on p. 515 for key to numbers)	5, 12, 18, 27, 33, 42, 51, 58, 60, 64, 69, 77	20, 68			16, 24, 48	1, 6, 21, 26, 32, 34, 35, 36	6, 21, 26, 34, 36	6, 26, 34, 35, 36	6, 34, 36

LIST OF MANUFACTURERS OF FOAMED PLASTICS

1. American Latex Products, Inc., 3341 W. El Segundo Blvd., Hawthorne, Calif.
2. American Rubber Products Corp., La Porte, Ind.
3. Atlas Mineral Products Co., Mertztown, Pa.
4. Badische Anilin & Soda-Fabrik AG, Ludwigshafen am Rhein, Germany
5. Bradley and Vrooman Co., 2629 S. Dearborn St., Chicago 16, Ill.
6. Brown Rubber Co., Inc., Lafayette, Ind.
7. Burkart Manufacturing Co., F., Div. of Textron Inc., 4900 N. Second St., St. Louis 7, Mo.
8. Burnett and Co., Inc., W. T., Baltimore 30, Md.
9. California Ink Co., Inc., 545 Sansone St., San Francisco, Calif.
10. Cambridge Rubber Co., Taneytown, Md.
11. Chase Chemical Corp., 3527 Smallman St., Pittsburgh 1, Pa.
12. Chemical Products Corp., King Philip Rd., E. Providence 14, R. I.
13. Colton Chemical Co., a Div. of Air Reduction Co., Inc., 1747 Chester Ave., Cleveland 14, Ohio
14. Crest Chemical Industries Corp., 72 Delavan St., Brooklyn 31, N.Y.
15. Curtiss-Wright Corp., Carlstadt, N. J.
16. D & R Pilot Plants, Inc., Hazardville, Conn.
17. Dayton Rubber Co., Dayton, Ohio
18. Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo.
19. Dow Chemical Co., The, Midland, Mich.
20. Dow Corning Corp., Midland, Mich.
21. Dryden Rubber Div., Sheller Manufacturing Corp., 1014 S. Kildare Ave., Chicago 24, Ill.
22. Dunlop Tire and Rubber Co., Buffalo, N.Y.
23. Dura-Flex Co., 2043 Colorado Ave., Santa Monica, Calif.
24. Emerson and Cuming, Inc., 869 Washington St., Canton, Mass.
25. Federal Industries, Div. of Textron Inc., Belleville 9, N.J.
26. Firestone Rubber & Latex Products Co., Div. of Firestone Tire & Rubber Co., Fall River, Mass.
27. Flexible Products Co., P.O. Box 306, Marietta, Ga.
28. Foam King, Inc., 1816 Boston Rd., Bronx 60, N.Y.
29. Frank Plastics Corp., 2941 E. Warren Ave., Detroit 7, Mich.
30. General Tire & Rubber Co., Bolta Products Div., Lawrence, Mass.
31. General Tire & Rubber Co., Chemical Div., Akron, Ohio
32. General Tire & Rubber Co., Industrial Products Div., Marion, Ind.
33. B.F. Goodrich Co., Akron 8, Ohio
34. B.F. Goodrich Sponge Products, Shelton, Conn.
35. Goodyear Tire & Rubber Co., 1210 Massilon Rd., Akron 15, Ohio
36. Great American Industries, Inc., Rubatex Div., Bedford, Va.
37. Hachman Corp., 4560 W. Armitage Ave., Chicago, Ill.
38. Hadley Bros. — Uhl Co., Calvary at Altman Sts., St. Louis, Mo.
39. Hewitt-Robins, Inc., Buffalo, N.Y.
40. Hood Sponge Rubber Co., 340 W. Huron St., Chicago 10, Ill.
41. Hudson Foam Products, Saw Mill River Rd. & Lake Ave., Yonkers, N.Y.
42. Interchemical Corp., Finishes Div., P.O. Box 659, Newark 1, N.J.
43. Isocyanate Products, Inc., P.O. Box 1681, Wilmington, Del.
44. Koppers Co., Inc., Plastics Division, Product Development, P.O. Box 65, Monaca, Pa.
45. Lebec Chemical Corp., 14066 S. Garfield, Paramount, Calif.
46. Loven Chemical of California, Newhall, Calif.
47. Magic Chemical Co., 100 Crescent St., Brockton 2, Mass.
48. Marblette Corp., 37-21 30th St., Long Island City 1, N.Y.
49. Minnesota Mining & Mfg. Co., Adhesives, Coatings, and Sealers Div., 900 Bush Ave., St. Paul 6, Minn.
50. Mobay Chemical Co., 1815 Washington Rd., Pittsburgh 34, Pa.
51. Mono-Sol Corp., 407 County Line Rd., Gary, Ind.
52. Naugatuck Chemical Co., Div. of U.S. Rubber Co., Naugatuck, Conn.
53. Nopco Chemical Co., Plastics Div., 175 Schuyler Ave., N. Arlington, N.J.
54. Paramount Foam Industries, 525 Oritan Ave., Ridgefield, N.J.
55. Parcloid Chemical Co., 31 Cross Ave., Midland Park, N.J.
56. Pelron Corp., 7847 W. 47th St., Lyons, Ill.
57. Pittsburgh Plate Glass Co., Paint Div., One Gateway Center, Pittsburgh 22, Pa.
58. Poly Resins, 11661 Wicks St., Sun Valley, Calif.
59. Reichhold Chemicals, Inc., RCI Bldg., White Plains, N.Y.
60. Reynolds Chemical Products Co., 1200 N. Main St., Ann Arbor, Mich.
61. Rezolin, Inc., 5736 W. 96th St., Los Angeles 45, Calif.
62. Robinson Foams Ltd., 183 George St., Toronto, Ont., Canada
63. Robinson Moulded Products Ltd., 183 George St., Toronto, Ont., Canada
64. Rubber Corp. of America, New South Rd., Hicksville, N.Y.
65. Schwab Plastics Corp., 730 S. Dix, Detroit 17, Mich.
66. Seatt Paper Co., Front & Broomall Sts., Chester, Pa.
67. Sheller Manufacturing Corp., Portland, Ind.
68. Standard Plastics, Inc., Fogelsville, Pa.
69. Stanley Chemical Co., E. Berlin, Conn.
70. Strux Corp., 37 W. John St., Hicksville, N.Y.
71. Styrene Products Ltd., 170 Piccadilly, London W.1, England
72. Sun Rubber Co., Barberton, Ohio
73. Thiokol Chemical Corp., 780 N. Clinton, Trenton 7, N.J.
74. Trostel and Sons Co., Inc., Albert, Milwaukee, Wis.
75. Union Carbide Plastics Co., a Div. of Union Carbide Corp., 212 Wright St., Newark 5, N.J.
76. U.S. Rubber Co., Mishawaka, Ind.
77. Watson-Standard Co., 225 Galveston Ave., Pittsburgh 30, Pa.
78. Westlake Plastics Co., Lenni Mills, Pa.
79. Witco Chemical Co., 122 E. 42nd St., New York 17, N.Y.

WHEN USING the Adhesives Chart, the reader must keep in mind that the listing of bonding agents by specific chemical families is simply a method of presenting cumulative data in convenient and compact form. Many commercial adhesives are complex mixtures of different

TYPE OF PLASTIC BASE	BONDING CLASSIFICATION[a]	SOLVENTS[b]	RESISTANCE RATING[c]					EFFECTIVENESS[c] OF BOND WITH:							
			Water	*Solvents*	*Heat*	*Cold*	*Fungus*	*Wood*	*Metals*	*Rubber*	*Glass*	*Leather*	*Paper*	*Textiles*	*Ceramics*
1. Acrylate and methacrylate resins															
1a. Ethyl acrylate	SR	E, K	E	F	P	G	E	G	F	P	G	G	G	G	G
1b. *n*-Butyl methacrylate	SR, F	Cl, E, H, HA, K	E	F	F	G	E	G	F	G	G	G	G	G	G
1c. Isobutyl methacrylate	SR, F	Cl, E, H, HA, K	E	F	M	G	E	G	F	P	G	G	G	G	G
1d. Ethyl methacrylate	SR, F	Cl, E, H, K	E	F	M	G	E	M	F	M	G	G	E	G	M
1e. Methyl methacrylate	SR, F	Cl, E, H, K	E	F	G	G	E	P	P	M	P	G	E	E	F
1f. Methyl cyanoacrylate	R	None needed	M	G	F	G	–	E	E	E	E	F	P	P	E
2. Alkyd resins	SR, F	E, H, W	G	M	P	M	E	G	M	G	G	E	E	E	M
3. Animal glue	SR	W	P	E	M	G	F	E	P	P	M	E	E	E	P
4. Asphalt	H, W	H, HA	G	P	P	G	E	M	G	G	G	M	G	G	F
5. Blood															
5a. Blood albumin	SR M	W W	P M	G G	F M	F M	F F	F G	P G	P P	P P	G G	G G	G E	P P
5b. Soluble dried blood	SR M	W W	P M	G G	F M	F M	F F	M G	P G	P P	P P	G E	G E	G E	F P
6. Casein	CR, SR	W	M	G	M	M	F	G	P	P	P	G	G	M	P
7. Cellulose derivatives															
7a. Cellulose acetate	SR, F	Cl, E, K	F	M	G	F	E	M	P	P	P	G	E	G	F
7b. Cellulose acetate butyrate	SR, F	A + H, Cl, E, N, K	G	F	F	F	E	M	F	F	F	G	E	E	F
7c. Cellulose nitrate	SR	E, K (+ A, H)	F	F	M	F	E	G	F	P	M	E	E	E	M
7d. Ethyl cellulose	SR, F	A, E, H, K	G	P	F	E	E	F	M	G	P	M	E	G	P
7e. Hydroxyethyl cellulose	SR, F	W	P	E	G	G	M	–	–	F	–	G	E	E	G
7f. Methyl cellulose	SR	W	P	E	M	G	E	M	P	F	P	M	E	M	P
7g. Sodium carboxymethyl cellulose	SR	W	P	E	M	G	F	–	–	–	–	–	–	–	–
8. Coumarone-indene resins	SR, F	Cl, E, H, K, W	E	P	F	M	E	M	G	G	G	G	G	G	F
9. Epoxy resins	CR, H, M, R	None needed	E	E	G	E	E	E	E	G	E	E	E	E	E
10. Furan resins (furfuryl alcohol or furfural-ketone)	R H CR	A, K, Cl A, K, Cl A, K, Cl	E E E	E E E	E E E	E M M	E E E	G E E	P P F	G G P	M M G	M G M	E M P	E E P	E E E
11. Gum arabic	SR	W	P	M	F	F	P	F	P	P	P	M	E	M	P
12. Petroleum polymer resins	SR, F	Cl, E, H, HA, W	E	P	F	M	E	M	G	G	G	G	G	G	F
13. Isobutylene resins (polyisobutylene)	SR	H, HA	E	P	F	G	E	P	P	P	P	G	G	G	P

[a] Code for bonding classification: SR = Solvent released (from solution or emulsion); F = Fused by heating; V = Vulcanized; R = Cured at room temperature (70–80 °F.); M = Cured at moderate temperature (150–200 °F.); H = Cured at elevated temperature (275–310 °F.); CR = Chemically reacted.

resins, compounded to attain a combination of properties not found in a single type of base. Choice of an adhesive for a specific bonding job should be made only after consulting manufacturers of adhesives which fall within the desired area.

TRADE DESIGNATIONS	MANUFACTURERS OR SUPPLIERS OF RESINS OR ADHESIVES *(See list on pp. 522-3 for key to numbers)*
1.	
1a. Acrigrip (4), Acryloid (129), Catalin (38), CD Cement (41), Farrington (60), Hu-Glue (79), Lucite (55), Midland (90), Plastibond (71), Polybond (118), Rhoplex (129), Upaco (148)	2, 4, 20, 38, 41, 55, 60, 71, 79, 81, 87, 90,98, 112, 117, 118, 125, 134, 138, 148
1b. Acrigrip (4), Acryloid (129), Arcco (33), Bondmaster (131), Catalin (38), CD Cement (41), Cordo-Bond (47), Dennis (50), Hu-Glue (79), Lucite (55), Midland (90), Placco (33), Polybond (118), Polyco (33), Reslac (33), Rhoplex (129)	2, 4, 20, 33, 38, 41, 47, 50, 55, 79, 90, 98, 112, 117, 118, 120, 125, 131, 134
1c. Acrigrip (4), Bondmaster (131), CD Cement (41), Hu-Glue (79), Lucite (55), Midland (90), Polybond (118), Upaco (148)	2, 4, 20, 41, 55, 79, 90, 98, 112, 117, 118, 120, 125, 131, 134, 148
1d. Acrigrip (4), Acryloid (129), Catalin (38), CD Cement (41), Fuller (63), Lucite (55), Midland (90), Polybond (118), Rhoplex (129), Upaco (148)	2, 4, 20, 38, 41, 55, 63, 79, 90, 98, 112, 117, 118, 120, 125, 129, 134, 148
1e. Acrigrip (4), Acronal (25), Acryloid (129), Arcco (33), Bedacryl (80), Bondmaster (131), Bostik (26), Catalin (38), CD Cement (41), Compo (46), Fuller (63), Inceloid (13), Lebec (84), Loxite (158), Lucite (55), Midland (90), Placco (33), Polybond (118), Polyco (33), Reslac (33), Rez-N-Bond (134), Rhoplex (129), Tensol (80), Tygobond (151), Upaco (148)	2, 4, 13, 20, 25, 26, 33, 36, 38, 41, 46, 55, 63, 79, 80, 81, 84, 90, 98, 112, 117, 118, 120, 125, 129, 131, 134, 138, 148, 151, 158
2. Alkydol (7), Fuller (63), G-E Glyptal (66), Midland (90), Miracle (94), Ohio (108), Paralac (80), Rubbagrip (130), Upaco (148)	4, 7, 17, 20, 24, 36, 63, 66, 80, 90, 94, 108, 125, 130, 148
3. API (5), Fedroflex (98), Fuller (63), Hallmark (140), Hu-Flex (79), Impervo (101), Layton (98), Midland (90), Paisley (98), Polybond (118), Stixo (63), Upaco (148)	5, 16, 19, 63, 76, 79, 90, 98, 101, 117, 118, 138, 140, 141, 148, 156
4. API (5), Arcco (33), Bondmaster (131), Cascola (33), Flintkote (61), Fuller (63), Indu-Sealz (103), Lebec (84), Midland (90), Miracle (94), Ohio (108), Placco (33), Residex (98), Resinex (73), Reslac (33), Transphalt (109), 3 M (92)	4, 5, 13, 20, 33, 61, 63, 73, 84, 90, 92, 94, 98, 103, 108, 109, 128, 131
5.	
5a. Hallmark (140)	19, 140, 142
5b. A-M (12), Hallmark (140), Monsanto (97), Plyacien (123)	12, 19, 97, 123, 140
6. A-M (12), API (5), Bindtite (76), Casco (33), Erie (73), Fedco (98), Fuller (63), Hu-Case (79), Impervo (101), Lauxein (97), Lebec (84), Lotol (103), Midland (90), Miracle (94), Monite (96), National Casein (102), Paisley (98), Perfection (110), Permaweld (117), Plyacien (123), Polybond (118), Upaco (148)	4, 5, 12, 16, 33, 63, 73, 76, 84, 87, 90, 94, 96, 97, 98, 101, 102, 108, 110, 117, 118, 123, 138, 141, 142, 148
7.	
7a. API (5), Arcco (33), Bondmaster (131), CD Cement (41), Farrington (60), Hercules CA (74), Midland (90), Miracle (94), Ohio (108), Placco (33), Plastibond (71), Plastigrip (4), Plastite (115), Polybond (118), Randolph (122), Reslac (33), Resyn (101), Rez-N-Bond (134), Rubbagrip (130), Slomons (138), Tenite Acetate (57, 144), Upaco (148), Vinylgrip (4)	4, 5, 15, 24, 33, 41, 55, 57, 60, 71, 74, 90, 94, 97, 101, 108, 112, 115, 117, 118, 120, 121, 122, 125, 130, 131, 134, 138, 148
7b. Cellugrip (4), CD Cement (41), Cordobond (47), Hu-Glue (79), Midland (90), Plastibond (71), Plastigrip (4), Rez-N-Bond (134), Tenite Butyrate (57, 144)	4, 33, 41, 47, 57, 63, 71, 79, 90, 112, 117, 120, 121, 125, 134, 148, 156
7c. API (5), Arcco (33), Bond (32), Bondmaster (131), Bostik (26), CD Cement (41), Celloweld (117), Compo (46), Dennis (50), Duco (55), Farrington (60), Fuller (63), Herculoid (74), Inceloid (13), Jack The Giant Killer (138), Midland (90), Miracle (94), Ohio (108), Placco (33), Plastigrip (4), Plastite (115), Polybond (118), Randolph (122), Reslac (33), Resyn (101), Upaco (148)	4, 5, 13, 15, 16, 26, 32, 33, 41, 46, 50, 55, 60, 63, 74, 79, 87, 90, 94, 97, 98, 101, 108, 112, 115, 117, 118, 120, 121, 122, 125, 131, 134, 138, 148
7d. API (5), CD Cement (41), Cellugrip (4), Compo (46), Ethocel (52), Farrington (60), Fuller (63), Hercules EC (74), Inceloid (13), Midland (90), Plastibond (71), Plastigrip (4), Polybond (118), Resyn (101), Rez-N-Bond (134), Spotseal (98)	4, 5, 13, 15, 16, 33, 41, 46, 52, 60, 63, 71, 74, 79, 90, 98, 101, 112, 117, 118, 120, 121, 125, 134, 138, 141, 148, 156
7e. Cellosize (146), Midland (90), Polybond (118)	90, 112, 117, 118, 125, 146, 148
7f. Bond (32), Midland (90), Paisley (98), Polybond (118)	4, 16, 32, 52, 69, 90, 98, 112, 117, 118, 125, 138, 141, 148
7g. Cellofas (80), Hercules CMC (74), Midland (90)	4, 36, 55, 74, 80, 90
8. Arcco (33), Bondmaster (131), Bunarex (109), Cumar (8), Epok (34), Fuller (63), Gripweld (4), Midland (90), Miracle (94), Nevindene (104), Nevillac (104), Neville (104), Ohio (108), Paradene (104), Picco (109), Piccoumaron (109), Piccovar (109), Placco (33), Polybond (118), Reslac (33), Resyn (101), Rez-N-Bond (134), Upaco (148), Velsicol (154)	4, 8, 15, 16, 33, 34, 63, 73, 79, 90, 94, 101, 104, 108, 109, 112, 117, 118, 125, 131, 134, 148, 154
9. Adgrip (4), Alfane (22), Alk-O-Flax (7), Amphesive (22), Araldite (44), Aritemp (18), Bakelite (147), Bond (32), Bondarc (20), Bonding Agent (28), Bondmaster (131), BRC (31), Brushmaster (131), Carboline (37), Cardolite (93), CD Cement (41), Cellobond (34), Cepox (41), Chemo Tec (118), Cordo-Bond (47), Corrocote (40), Cycleweld (49), Duro-lok (101), Eccobond (58), Epibond (64), Epiphen (33), Epocast (64), Epolac (83), Epolite (127), Epoloy (127), Epon (136), Epotuf (123), Epoxylite (59), Goodrich, B.F. (69), Homalite (77), Hysol (78), Lithgow (85), Loven (86), Maraglas (88), Maraset (88), Metalfil (3), Metlbond (100), Midland (90), Miracle (94), Multiplastics (99), Narmco (100), Nureco (107), Ohio (108), Paisley (98), Plymaster (131), Polyox (123), Poly-Preg (116), Pylene (118), Randolph (122), Ren (124), Resiweld (63), Rezolin (127), Sealweld (91), Stabond (10), Styrobond (100), Styroseal (100), Tygofil (151), Tygoweld (151), Tylene (144), 3 M (92)	3, 4, 7, 10, 15, 18, 20, 21, 22, 24, 28, 31, 32, 33, 34, 37, 40, 41, 44, 49, 58, 59, 60, 63, 64, 69, 77, 78, 79, 83, 85, 86, 87, 88, 90, 91, 92, 93, 94, 98, 99, 100, 101, 107, 108, 112, 116, 117, 118, 122, 123, 124, 125, 127, 131, 136, 138, 139, 144, 147, 151, 156
10. Carboline (37), Corrocote (40), Duralon (151), Durez (56), Fura-Tone (93), Helix (28), Loven (86), Plenco (114), Resin X (64), Synvar (143), Varcum (153)	28, 37, 40, 56, 64, 86, 87, 93, 102, 114, 143, 151, 153,
11. Fedrogum (98), Fuller (63), Hallmark (140), Midland (90), Polybond (118), Solubic (98), Upaco (148)	48, 63, 90, 98, 101, 105, 118, 138, 140, 141, 148
12. Bond Cement #2210 (32), Bondmaster (131), Loxite (157), LR-16 (109), Midland (90), Miracle (94), Nebony (104), Neville (104), Ohio (108), Panarez (14), Piccopale (109), Polybond (118), Resyn (101), Velsicol (154)	14, 32, 33, 73, 79, 90, 94, 101, 104, 108, 109, 112, 117, 118, 125, 131, 138, 154, 156, 157
13. API (5), Arcco (33), Bondmaster (131), Fuller (63), Goodrich, B.F. (69), Loxite (157), Midland (90), Oppanol B (25, 106), Placco (33), Pliastic (98), Polybond (118), Reslac (33), Resyn (101), Upaco (148)	5, 15, 16, 33, 55, 63, 69, 79, 90, 92, 98, 101, 106, 117, 118, 120, 125, 131, 148, 156, 157

[b] Code for solvents: A = Alcohols; Cl = Chlorinated hydrocarbons; E = Esters; H = Aromatic hydrocarbons; HA = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water (solution or emulsion).

[c] Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair; P = Poor.

TYPE OF PLASTIC BASE	BONDING CLASSIFICATION[a]	SOLVENTS[b]	RESISTANCE RATING[c]					EFFECTIVENESS[c] OF BOND WITH:							
			Water	*Solvents*	*Heat*	*Cold*	*Fungus*	*Wood*	*Metals*	*Rubber*	*Glass*	*Leather*	*Paper*	*Textiles*	*Ceramics*
14. Isocyanate resins (polyurethanes)	H, R, M	Cl, E, H, K	E	E	E	E	E	E	E	E	E	E	E	E	E
15. Melamine resins															
15a. Melamine-formaldehyde	H	A, W	E	E	E	E	E	E	P	P	P	G	E	E	F
15b. Melamine-urea-formaldehyde	H	W	E	E	E	E	E	E	P	P	P	E	E	E	M
16. Oleo-resins	SR, R	H	G	G	G	M	E	G	G	P	G	G	G	G	G
17. Phenolic resins															
17a. Phenol-formaldehyde	R	A, K, W	E	E	G	G	E	M	P	E	P	M	M	M	G
	M	A, K, W	E	E	E	E	E	E	P	E	P	G	G	G	G
	H	A, K, W	E	E	E	E	E	E	P	E	P	E	E	E	G
17b. Phenolic-elastomer	SR, R	Cl, K	E	G	G	E	E	E	G	G	G	E	E	E	G
	M	Cl, K	E	G	G	E	E	G	M	G	G	G	E	G	G
	F, H	Cl, K	E	E	E	E	E	E	E	G	G	G	E	E	E
17c. Phenolic-epoxy	H, CR	None needed	E	E	E	E	E	E	E	F	E	E	G	E	E
17d. Phenolic-polyamide	F, H	A	P	F	M	E	E	E	E	P	P	F	P	F	F
17e. Phenolic-vinyl acetals	M, H	A, H, K	E	E	G	M	E	E	E	G	F	G	E	E	E
18. Polyamide resins															
18a. Polyamides	SR, F	Alcohols > C_2	E	G	M	G	E	E	E	–	G	G	E	G	G
18b. Polyamide-epoxy	M, R, SR CR, H	None or A + K	E	E	G	E	E	E	E	G	E	E	E	E	E
19. Polyester resins															
19a. Polyesters (unsaturated)	H	A, E, H, K	G	E	M	M	E	M	E	F	E	M	E	E	M
19b. Polyester-elastomer	H, R	None needed	E	E	E	M	E	E	F	M	G	E	E	E	M
— Polyisobutylene (see Isobutylene resins)															
— Polyethylene oxide	SR	W, few Cl, E	E	E	P	E	E	P	P	F	P	G	G	G	G
20. Resorcinol resins															
20a. Resorcinol-formaldehyde	R	A, K, W	E	E	E	E	E	E	P	M	P	E	E	E	F
	M	A, K, W	E	E	E	E	E	E	P	M	P	E	E	E	F
20b. Resorcinol-furfural	R	A, W	E	E	E	E	E	E	P	E	P	G	E	E	F
20c. Resorcinol-phenol-formaldehyde	R	A, K, W	E	E	E	E	E	E	P	M	P	E	E	E	F
	M	A, K, W	E	E	E	E	E	E	P	M	P	E	E	E	F
20d. Resorcinol-polyamide	R	A, W	E	E	E	E	E	E	F	E	F	E	E	E	M
20e. Resorcinol-urea	M	W	G	E	G	G	E	G	P	G	P	E	E	E	M
21. Rubbers															
21a. Natural rubber	SR	Cl, H, HA, W	G	F	F	G	E	F	M	G	G	G	G	G	F
	V	Cl, H, HA, W	G	M	M	G	E	F	F	E	G	G	G	E	F
21b. Reclaimed rubber	SR	Cl, H, HA, W	E	F	F	G	E	G	G	G	M	G	G	E	E
	V	Cl, H, W	M	F	G	G	E	G	M	G	M	G	G	E	F
21c. Chlorinated rubber	SR, F	E, H, K	E	P	M	M	E	M	M	G	M	M	G	G	P
21d. Cyclized rubber	SR, F	Cl, H	E	F	F	M	E	F	M	E	P	P	E	E	P

[a] Code for bonding classification: SR = Solvent released (from solution or emulsion); F = Fused by heating; V = Vulcanized; R = Cured at room temperature (70–80°F.); M = Cured at moderate temperature (150–200°F.); H = Cured at elevated temperature (275–310°F.); CR = Chemically reacted.

TRADE DESIGNATIONS	MANUFACTURERS OR SUPPLIERS OF RESINS OR ADHESIVES (*See list on pp. 522-3 for key to numbers*)
14. Adlok (4), Bondmaster (131), Corrocote (40), Epolac (83), Flexweld (145), Goodrich, B.F. (69), Loven (86), Mondur (95), Mondur/Multron (95), Multranil (95), Polybond (118), Polylite (123), Polyweld (4), Vulcabond (10)	4, 20, 26, 33, 34, 36, 40, 69, 80, 83, 86, 87, 95, 117, 118, 123, 125, 131, 145
15.	
15a. Amres (12), Catalin (38), Cellobond (34), Cymel (9), Diaron (123), Lauxite (97)	9, 12, 34, 38, 87, 97, 110, 123, 125
15b. Amres (12), Catalin (38), Cellobond (34), Lauxite (97), Melurac (9), Uformite (129)	9, 12, 34, 38, 97, 102, 110, 125, 129
16. Bondmaster (131), Lithgow (85), Midland (90), Miracle (94), Ohio (108), Paisley (98), 3 M (92)	20, 61, 63, 85, 90, 92, 94, 98, 108, 125, 131
17.	
17a. Acme (1), Amberlite (129), Amres (12), Bakelite (147), Bedesol (80), Bondmaster (131), Cascophen (33), Catalin (38), Cellobond (34), Durez (56), Durite (33), Forasite (123), Goodrich, B.F. (69), Heresite (75), Kanresin (25), Lauxite (97), Lebec (84), Loven (86), Marblette (88), Marbon (89), Midland (90), National Casein (102), Paisley (98), Plaskon (8), Plasticweld (85), Plenco (114), Plyophen (123), Rubbagrip (130), Schenectady (133), Stixgrip (4), Synco (142), Synvarite (143), Tego (129), Tybon (12), Upaco (148), Varcum (153), 3 M (92)	1, 4, 8, 12, 15, 20, 25, 33, 34, 36, 38, 56, 66, 69, 75, 80, 84, 85, 86, 87, 88, 89, 90, 92, 97, 98, 102, 110, 114, 117, 123, 125, 129, 130, 131, 133, 134, 142, 143, 147, 148, 153
17b. Acme (1), Bondmaster (131), Bostik (26), BRC (31), Compo (46), Corrocote (40), Cycleweld (49), Dennis (50), Durite (33), FM (31), Fuller (63), Glu-Ply (79), Lauxite (97), Loxite (157), Metlbond (100), Midland (90), Narmtape (100), Permabond (117), Plastilock (69), Pliobond (70), Pliobond HT (70), Pliogrip (70), Pliotac (70), Plymaster (131), Polybond (118), Redux (44), Resyn (101), RS (89), Rubbagrip (130), Stabond (10), Stixgrip (4), Upaco (148), 3 M (92)	1, 4, 10, 15, 20, 26, 31, 33, 40, 44, 46, 49, 50, 69, 70, 79, 83, 84, 89, 92, 97, 100, 101, 112, 116, 117, 118, 125, 130, 131, 134, 141, 142, 143, 148, 157
17c. Acme (1), Adlok (4), Aerobond (3), BRC (31), Lebec (84), Metlbond (100), Midland (90), Plastilock (69), Plenco (114), Plyophen (123), Polybond (118), Stabond (10), Tygoweld (151)	1, 3, 4, 10, 20, 31, 69, 84, 90, 100, 114, 118, 123, 125, 151,
17d. Acme (1), Alk-O-Flex (7), Bondmaster (131), Cycleweld (49), Lithgow (85), Metlbond (100), Midland (90), Polybond (118), Schenectady (133)	1, 7, 33, 49, 79, 85, 90, 100, 112, 117, 118, 125, 131, 133
17e. Acme (1), Arcco (33), Bondmaster (131), Bostik (26), BRC (31), Compo (46), Cycleweld (49), Goodrich, B.F. (69), Midland (90), Placco (33), Plycozite (149), Polyco (33), Redux (6), Reslac (33), Schenectady (133), Synco (142)	1, 4, 6, 15, 20, 26, 31, 33, 46, 49, 69, 90, 112, 117, 125, 131, 133, 142, 149
18.	
18a. Adlok (4), Arcco (33), BCI (27), Bondmaster (131), CD Cement (41), Corrocote (40), Epolac (83), Fuller (63), Midland (90), Miracle (94), Nylaweld (119), Ohio (108), Paisley (98), Placco (33), Plastibond (71), Polybond (118), Reslac (33), Resyn (101), Upaco (148), Versamid (68)	4, 20, 26, 27, 33, 40, 41, 63, 68, 71, 79, 83, 87, 90, 94, 98, 101, 108, 112, 118, 119, 120, 125, 131, 141, 148
18b. Adlok (4), Aerobond (3), Arcco (33), Aritemp (18), Bondmaster (131), CD Cement (41), Corrocote (40), Duro-lok (101), Eccobond (58), Epolac (83), Goodrich, B.F. (69), Hysol (78), Loxite (157), Metalfil (3), Midland (90), Miracle (94), Narmco (100), Nureco (107), Ohio (108), Placco (33), Plastibond (71), Polybond (118), Randolph (122), Resiweld (63), Reslac (33), Stabond (10), Tylene (144)	3, 4, 10, 15, 18, 20, 32, 33, 40, 41, 50, 58, 63, 68, 69, 71, 78, 79, 83, 90, 92, 94, 100, 101, 107, 108, 118, 122, 125, 131, 144, 157
19.	
19a. Bonding Agent (28), Bondmaster (131), Cellobond (34), Daltolac (80), Gripweld (4), Loven (86), Multiplastics (99), Nureco (107), Palatal P (25), Polylite (123)	4, 25, 28, 33, 34, 36, 39, 55, 80, 86, 98, 99, 107, 123, 131, 138
19b. Atlac (23), Carboline (37), Gripweld (4), Hexaplas (80), Marco Resin (39), Paraplex (129), Plaskon (8), Polylite (123), Selectron (113), Synvar-V (143)	2, 8, 23, 25, 33, 36, 37, 39, 80, 113, 123, 125, 129, 143
— Polyox (146)	146
20.	
20a. Amberlite (129), Amres (12), Bostik (26), Cascophen (33), Catalin (38), CD Cement (41), Cellobond (34), Cordo-Bond (47), Durez (56), Durite (33), Goodrich, B.F. (69), Lauxite (97), Lotol (103), Loxite (157), Midland (90), National Casein (102), Paisley (98), Penacolite (82), Plyophen (123), Resinox (97), Resorsabond (12), Rezoform (117), Schenectady (133), Synco (142), Synvaren (143), Varcum (153), Weldwood Resorcinol (149)	12, 15, 26, 33, 34, 38, 41, 56, 69, 82, 87, 90, 97, 98, 102, 103, 110, 117, 123, 125, 129, 133, 142, 143, 149, 153, 157
20b. Durite (33)	33, 142
20c. Amres (12), Bakelite (147), Cascophen (33), Catalin (38), Durez (56), Lauxite (97), National Casein (102), Penacolite (82), Plyophen (123), Resinox (97), Resorsabond (12), Synvarite (143), Varcum (153), Weldwood Phenol-Resorcinol (149)	4, 12, 15, 33, 38, 56, 82, 97, 102, 110, 117, 123, 125, 142, 143, 147, 149, 153
20d. Bondmaster (131), Penacolite (82)	82, 125, 131
20e. Casco-Resin (33), National Casein (102), Plankon (8), Synvarol (143), Uformite (129)	8, 33, 110, 125, 129, 142, 143
21.	
21a. Adco (4), Adrub (4), Anodex (69), API (5), Arcco (33), Baytex (145), Bond (32), Bondmaster (131), Bondrite (145), Bostik (26), BRC (31), Brushmaster (131), Casco (33), Compo (46), Corrocote (40), Dab-it (138), Darex (51), Dennis (50), Farrington (60), Fedco (98), Fedrobond (98), Fuller (63), Goodrich, B.F. (69), Inceloid (13), Laco (83), Lebec (84), Lotol (103), Loxite (157), Midland (90), Miracle (94), Ohio (108), Permaweld (117), Placco (33), Plastite (115), Pliastic (98), Pliotex (90), Polybond (118), Reslac (33), Resyn (101), Rubbagrip (130), Rubbatex (130), Stabond (10), Thixon (73), Treadmaster (131), Triple (15), Typly (89), U-Glu (138), Upaco (148), Vultex (67), 3 M (92), No. 9 Rubber Patching (138)	4, 5, 10, 13, 15, 16, 20, 26, 31, 32, 33, 40, 46, 50, 51, 60, 63, 67, 69, 73, 79, 83, 84, 87, 89, 90, 92, 94, 98, 101, 102, 103, 108, 115, 117, 118, 125, 130, 131, 132, 134, 138, 145, 148, 156, 157
21b. Adflex (4), Arcco (33), Bond Cement #936 (32), Bondmaster (131), Bostik (26), BRC (31), Casco (33), Cycleweld (49), Dispersite (103), Fuller (63), Indu-Sealz (103), Iron Bound (138), Loxite (157), Midland (90), Miracle (94), Ohio (108), Permaweld (117), Placco (33), Plastikon (69), Plastite (115), Pliastic (98), Pliotex (90), Polybond (118), Reslac (33), Resyn (101), Rubbatex (130), Thixon (73), Upaco (148), 3 M (92)	4, 15, 20, 26, 31, 32, 33, 49, 63, 69, 73, 90, 92, 94, 98, 101, 103, 108, 115, 117, 118, 125, 130, 131, 134, 138, 141, 148, 150, 157
21c. Adweld (4), Alloprene (80), Arcco (33), Bondmaster (131), Bostik (26), BRC (31), Carboline (37), CD Cement (41), Laco (83), Loven (86), Loxite (157), Midland (90), Miracle (94), Ohio (108), Parlon (74), Permaweld (117), Placco (33), Plastilock (69), Plastite (115), Pliastic (98), Polybond (118), Reslac (33), Rubbagrip (130), Stabond (10), Texkote (116), Typly (89), Upaco (148)	4, 10, 15, 20, 26, 31, 33, 36, 37, 41, 69, 74, 79, 80, 83, 86, 90, 94, 98, 108, 112, 115, 116, 117, 118, 120, 125, 130, 131, 145, 148, 157
21d. Alpex (7), Bondmaster (131), Bostik (26), Fuller (63), Permaweld (117), Pliastic (98), Polybond (118), Typly (89), Vulcalock (69)	4, 7, 15, 26, 33, 63, 69, 98, 112, 117, 118, 120, 125, 131, 145, 148

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[b] Code for solvents: A = Alcohols; Cl = Chlorinated hydrocarbons; E = Esters; H = Aromatic hydrocarbons; HA = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water (solution or emulsion).

[c] Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair; P = Poor.

TYPE OF PLASTIC BASE	BONDING CLASSIFICATION[a]	SOLVENTS[b]	RESISTANCE RATING[c]					EFFECTIVENESS[c] OF BOND WITH:							
			Water	*Solvents*	*Heat*	*Cold*	*Fungus*	*Wood*	*Metals*	*Rubber*	*Glass*	*Leather*	*Paper*	*Textiles*	*Ceramics*
21e. Butadiene-acrylonitrile rubber	SR, F	C1, H, K, W	G	E	G	G	E	G	E	G	G	G	G	E	M
	V	C1, H, K	G	E	G	M	E	G	E	G	G	G	G	E	M
21f. Butadiene-styrene rubber	SR, V	C1, H, HA, K, W	G	F	M	M	E	G	M	G	M	G	E	E	F
21g. Butyl rubber	SR	H, W	G	F	G	M	G	F	M	G	M	G	E	E	M
	V	H	G	F	G	M	G	F	M	M	M	G	E	E	F
21h. Neoprene rubber (polychloroprene)	SR, R	C1, E, H, HA, K, W	E	G	G	G	E	E	M	E	F	E	E	E	M
	V	C1, E, H, K	E	G	E	G	E	E	G	E	P	E	E	E	F
21i. Polysulfides (Thiokol)	SR	C1, H, W	M	M	M	M	E	M	F	M	F	M	M	M	P
	CR	C1, H	M	G	G	G	E	M	G	E	G	G	G	G	M
21j. Polysulfide-epoxy	CR, M, R	None	E	E	G	E	E	E	E	G	E	E	E	E	E
21k. Fluoride-containing rubber	SR, R, V	K	E	G	E	G	E	–	G	G	–	–	–	–	G
22. Shellac	F, SR	A	G	P	M	G	E	E	E	G	E	E	E	E	F
23. Silicone polymers															
23a. Silicone resins	H	H, K	E	F	E	G	G	–	G	–	G	–	–	–	G
23b. Silicone rubbers	R, V	H	E	P	G	E	E	–	E	–	E	–	–	E	E
24. Sodium silicate	M, SR	W	P	E	E	G	E	G	G	P	E	F	E	G	E
25. Soybean glue	SR	W	P	M	F	P	F	F	P	P	F	F	G	M	P
26. Starch and dextrin	SR	W	P	M	F	F	P	F	P	P	P	M	M	M	P
27. Styrene resins (polystyrene)	SR, F	C1, E, H, K, W	E	M	M	G	E	G	P	M	P	G	E	G	F
28. Terpene resins	SR, F	C1, E, H, HA, W	E	P	F	M	E	M	G	G	G	G	G	G	F
29. Urea resins															
29a. Urea-formaldehyde	R	W	M	E	M	E	E	E	P	P	P	G	E	E	P
	H	W	G	E	M	E	E	E	P	P	P	G	E	G	P
29b. Urea-formaldehyde-furfuryl alcohol	R	W	G	E	M	E	E	E	P	P	P	G	E	E	P
— Urethanes (see Isocyanate resins)															
30. Vinyl resins															
30a. Vinyl acetal	SR, F	A, E, H	G	M	F	G	E	G	E	M	E	E	E	E	G
30b. Vinyl acetate or vinyl alcohol-acetate	SR, F	A, C1, E, H, K, W	F	M	M	M	E	E	E	P	E	E	E	E	E
30c. Vinyl acetate copolymer	SR	A, C1, E, H, K, WA	M	M	P	M	E	G	M	F	M	G	G	G	P
30d. Vinyl alcohol	SR	A, W	F	E	G	M	E	M	P	P	P	G	E	G	G
30e. Vinyl alkyl ether	SR, F	A, C1, E, H, K, W	G	P	F	G	E	G	G	F	F	F	G	G	F
30f. Vinyl methyl ether-maleic anhydride copolymer	SR, F, CR	A, E, K, W	P	P	G	G	E	G	E	F	G	E	E	E	E

[a] Code for bonding classification: SR = Solvent released (from solution or emulsion); F = Fused by heating; V = Vulcanized; R = Cured at room temperature (70–80°F.); M = Cured at moderate temperature (150–200°F.); H = Cured at elevated temperature (275–310°F.); CR = Chemically reacted.

TRADE DESIGNATIONS	MANUFACTURERS OR SUPPLIERS OF RESINS OR ADHESIVES *(See list on pp. 522-3 for key to numbers)*
21e. Adweld (4), Anodex (69), API (5), Arcco (33), Bond (32), Bondmaster (131), Bostik (26), BRC (31), Brushmaster (131), Butakon (80), Carboline (37), Compo (46), Fedco (98), Fuller (63), Gripweld (4), Laco (83), Loxite (157), Marbon (89), Metlbond (100), Midland (90), Miracle (94), Narmtape (100), Nitrex (103), Ohio (108), Permaweld (117), Placco (33), Plastibond (71), Plastilock (69), Plastite (115), Pliastic (98), Pliobond (70), Pliogrip (70), Polybond (118), Polyco (33), Randolph (122), Reslac (33), Resyn (101), Rez-N-Bond (134), Rubbagrip (130), Stabond (10), Thixon (73), Tweezle (32), Tygobond (151), Tygoweld (151), Typly (89), Ubabond (145), Upaco (148), 3 M (92)	4, 5, 10, 15, 20, 26, 31, 32, 33, 37, 46, 55, 63, 67, 69, 70, 71, 73, 79, 80, 83, 89, 90, 92, 94, 98, 100, 101, 102, 103, 108, 112, 115, 117, 118, 120, 122, 125, 130, 132, 134, 145, 148, 150, 151, 156, 157
21f. Adprene (4), Anodox (69), API (5), Arcco (33), Baytex (145), Bondmaster (131), Bostik (26), BRC (31), Butakon (80), Casco (33), Cycleweld (49), Darex (51), Fedco (98), Fedrobond (98), Fuller (63), Goodrich, B.F. (69), Kralac (103), Kralastic (103), Laco (83), Loxite (157), Midland (90), Miracle (94), Naugapol (103), Naugatex (103), Ohio (108), Permaweld (117), Placco (33), Plastite (115), Pliastic (98), Pliogrip (70), Pliotex (90), Polybond (118), Polyco (33), Reslac (33), Resyn (101), Rez-N-Glue (134), Rubbatex (130), Typly (89), Ubapol (145), Upaco (148), 3 M (92)	4, 5, 15, 20, 26, 31, 32, 33, 49, 51, 63, 67, 69, 70, 79, 80, 83, 90, 92, 94, 98, 101, 103, 108, 112, 115, 117, 118, 120, 125, 130, 131, 132, 134, 141, 145, 148, 150, 156, 157
21g. API (5), Arcco (33), Bondmaster (131), Bostik (26), BRC (31), Dispersite (103), Fuller (63), Goodrich, B.F. (69), Gripweld (4), Inceloid (13), Laco (83), Lebec (84), Loxite (157), Midland (90), Miracle (94), Ohio (108), Permaweld (117), Placco (33), Plastite (115), Pliastic (98), Polybond (118), Reslac (33), Resyn (101), Thixon (73), Typly (89), Upaco (148), 3 M (92)	4, 5, 13, 15, 20, 26, 31, 33, 63, 69, 73, 79, 83, 84, 90, 92, 94, 98, 101, 103, 108, 112, 115, 117, 118, 120, 125, 131, 148, 150, 157
21h. Adweld (4), Anodex (69), API (5), Arcco (33), Baytex (145), Bondmaster (131), Bostik (26), BRC (31), Carboline (37), Casco (33), Compo (46), Cycleweld (49), Darex (51), Dennis (50), Fairprene (55), Fedco (98), Fedrobond (98), Formica Contact Bond (62), Formica Fast Dry Contact Bond (62), Formica Safe Bond Contact Cement (62), Fuller (63), Goodrich, B.F. (69), Gripweld (4), Laco (83), Lebec (84), Lotol (103), Loxite (157), Midland (90), Miracle (94), Neelium (22), Neobon (22), Nu-Rub (4), Ohio (108), Permaweld (117), Placco (33), Plastite (115), Pliastic (98), Pliobond (70), Pliotex (90), Polybond (118), Randolph (122), Reslac (33), Resyn (101), Rez-N-Glue (134), Rubbagrip (130), Stabond (10), Stix (4), Stixgrip (4), S-1200 Contact Bond (20), Thixon (73), Typly (89), Ubagrip (145), Upaco (148), U-Sement (150), Weldwood Contact Cement (149), 3 M (92)	4, 5, 10, 15, 16, 20, 26, 31, 33, 37, 46, 49, 50, 51, 55, 62, 63, 67, 69, 70, 73, 79, 83, 84, 90, 92, 94, 98, 101, 103, 108, 112, 115, 117, 118, 122, 125, 130, 131, 132, 134, 138, 141, 145, 148, 149, 150, 157
21i. Bondmaster (131), Casco (33), Ecco (58), Fuller (63), Loven (86), Permaweld (117), Polybond (118), Thioment (22), Thixon (73), 3 M (92)	20, 22, 26, 33, 58, 63, 73, 86, 92, 117, 118, 131
21j. Aerobond (3), Chemotec (118), Concresive (3), Cordobond (47), Fuller (63), Loxite (157), Narmco (100), Polycast (118)	3, 20, 47, 63, 92, 100, 118, 157
21k. Viton (118)	118
22. —	15, 118, 148, 158
23.	
23a. Dow Corning (53), Plastite (115), Union Carbide (137)	53, 66, 87, 115, 137
23b. Dow Corning (53), Polybond (118), Union Carbide (137)	53, 66, 112, 118, 137
24. API (5), Loven (86), Midland (90), Paisley (98), Polybond (118), Stixso (111)	4, 5, 55, 79, 86, 90, 98, 111, 118, 138
25. A-M (12), API (5), Casco (33), Lauxein (97), Paisley (98), Plyacien (123), Upaco (148)	5, 12, 17, 33, 97, 98, 123, 148
26. Adex (98), API (5), Argo Polyose (48), Bent-Tite (110), Cascola (33), Corox (110), Fedex (98), Fuller (63), Hallmark (140), Midland (90), Nadex (101), Polybond (118), Residex (98), Speedyset (156), Upaco (148), No. 3748 (138)	4, 5, 16, 17, 20, 26, 33, 48, 63, 79, 87, 90, 98, 101, 110, 118, 138, 140, 141, 148, 156
27. Arcco (33), Bakelite (147), Bond (32), Bondmaster (131), Bostik (26), Catalin (38), CD Cement (41), Fuller (63), Inceloid (13), Koppers (82), Midland (90), Picco SF-140 (109), Piccoflex (109), Piccolastic (109), Piccotex (109), Placco (33), Polybond (118), Polyco (33), Reslac (33), Rez-N-Bond (134), Rez-N-Glue (134), Rubbagrip (130), Styfil (4), Styrogrip (4), Ubatol (145), Upaco (148), 3 M (92)	4, 13, 15, 16, 26, 32, 33, 38, 41, 52, 63, 73, 79, 82, 87, 90, 92, 97, 98, 109, 117, 118, 120, 121, 125, 130, 131, 134, 145, 147, 148
28. API (5), Arcco (33), Bondmaster (131), Dispersite (103), Loxite (157), Midland (90), Piccolyte (109), Placco (33), Polybond (118), Reslac (33), Schenectady (133)	5, 33, 73, 79, 90, 103, 109, 112, 118, 125, 131, 133, 157
29.	
29a. Amres (12), Bakelite (147), B.I.P. (29), Cascamite (33), Casco-Resin (33), Catalin (38), Cellobond (34), Cellument (96), Foramine (123), Formica Urac 185 (62), Formica Urea (62), Fuller (63), Ful-O-Mite (63), Griptite (4), Holdbest (76), Kaurit (25), Lauxite (97), Lebec (84), Loven (86), Midland (90), National Casein (102), Paralac (80), Permaweld (117), Plaskon (8), Plyamine (123), Polybond (118), Residex (98), Synco (142), Synvarol (143), Uformite (129), Urac (9), Uraform (117), Urecoll (25), Weldwood plastic resin (149)	4, 8, 9, 12, 25, 29, 33, 34, 36, 38, 62, 63, 76, 80, 84, 86, 90, 96, 97, 98, 102, 110, 117, 118, 123, 125, 129, 140, 142, 143, 147, 148, 149
29b. Casco-Resin (33), Catalin (38), National Casein (102), Plaskon (8), Plyamine (123), Urac (9)	8, 9, 33, 38, 102, 123, 125, 142
30.	
30a. Alvar (135), Bakelite (147), Bondmaster (131), Bostik (26), BRC (31), Compo (46), Fedco (98), Midland (90), Plastibond (71), Plymaster (131), Polybond (118), Resgrip (4), Rez-N-Glue (134), Upaco (148), U-Sement (150), Vinylgrip (4)	4, 15, 20, 26, 31, 46, 69, 71, 90, 97, 98, 112, 117, 118, 125, 131, 134, 135, 141, 147, 148
30b. Alk-o-mer (7), API (5), Arcco (33), Bakelite (147), Bond (32), Bondmaster (131), Bostik (26), Cascorez (33), CD Cement (41), Cellobond (34), Certus (96), Compo (46), Darex (51), Dennis (50), Elvacet (55), Fedco (98), Federez (98), Fuller (63), Gelva (135), Goodrich, B.F. (69), Griffin (72), Hallmark (140), Helix (28), Hewhold (76), Hu-Rez (79), Inceloid (13), Kotol (103), Kwik-Klamp (101), Lauxite (97), Lemac (33), Loxite (157), Metalgrip (4), Midland (90), Miracle (94), National Casein (102), Ohio (108), Placco (33), Plastibond (71), Plasticweld (85), Plastigrip (4), Plastite (115), Pliastic (98), Plyamul (123), Polybond (118), Polyco (33), Resgrip (4), Resiwood (63), Reslac (33), Resyn (101), Reynobond (126), Rez-N-Glue (134), Rubbagrip (130), Sobo (138), Speedbond (97), Stikit XX (122), Syn-tite (90), Synvac (142), Upaco (148), U-Sement (150), VC (134), Velverette (138), Vinac (45), Vinrez (140), Vinylgrip (4), Vinymul (98)	2, 4, 5, 7, 11, 13, 15, 16, 19, 20, 24, 26, 28, 32, 33, 34, 41, 45, 46, 50, 51, 55, 60, 63, 69, 71, 72, 76, 79, 85, 87, 90, 92, 94, 96, 97, 98, 101, 102, 108, 110, 112, 115, 116, 117, 118, 120, 121, 122, 123, 125, 126, 130, 131, 134, 135, 138, 140, 141, 142, 147, 148, 150, 156, 157
30c. API (5), Arcco (33), Bondmaster (131), Bostik (26), Cordobond (47), Elvacet (55), Fedco (98), Flexbond (45), Fuller (63), Goodrich, B.F. (69), Lemac (33), Midland (90), Paisley (98), Placco (33), Plastibond (71), Polybond (118), Polyco (33), Randolph (122), Resgrip (4), Reslac (33), Resyn (101), Slomons S-4 (138), Upaco (148), VC (134), Vinac (45), Vinrez (140), Vinylgrip (4), Weldwood Presto-Set (149)	4, 5, 20, 26, 32, 33, 45, 47, 55, 63, 69, 71, 79, 90, 98, 101, 118, 120, 121, 122, 125, 131, 134, 138, 140, 148, 149
30d. API (5), Darex (51), Elvanol (55), Fedco (98), Fedcol (98), Fuller (63), Gelvatol (135), Goodrich, B.F. (69), Hallmark (140), Lemol (33), Midland (90), Pliastic (98), Polybond (118), Resgrip (4), Resiflex (63), Resyn (101), Syn-tite (90), Upaco (148), Vinol (45), Vinylgrip (4)	4, 5, 16, 20, 33, 45, 51, 55, 63, 69, 79, 90, 98, 101, 112, 117, 118, 125, 135, 138, 140, 141, 148, 156
30e. Bakelite (147), Bond Cement #9262 (32), Bondmaster (131), Bostik (26), Lutonal (25), Oppanol C (25), Polybond (118), Prestix (4), Resyn (101), Upaco (148)	4, 15, 20, 25, 26, 32, 79, 101, 118, 125, 131, 147, 148, 156
30f. PVM/MA (65)	65

[b] Code for solvents: A = Alcohols; Cl = Chlorinated hydrocarbons; E = Esters; H = Aromatic hydrocarbons; HA = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water (solution or emulsion).

[c] Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair; P = Poor.

TYPE OF PLASTIC BASE	BONDING CLASSIFICATION[a]	SOLVENTS[b]	RESISTANCE RATING[c]					EFFECTIVENESS[c] OF BOND WITH:							
			Water	*Solvents*	*Heat*	*Cold*	*Fungus*	*Wood*	*Metals*	*Rubber*	*Glass*	*Leather*	*Paper*	*Textiles*	*Ceramics*
30g. Vinyl chloride	SR, F	A	M	M	M	M	E	E	E	G	E	E	E	E	E
30h. Vinyl butyral	SR, F	E, W	G	M	F	M	E	M	G	G	G	E	E	E	G
30i. Vinyl chloride-acetate copolymer	SR, F	E, K	E	G	G	G	E	G	G	M	G	E	E	E	G
30j. Vinyl propionate	SR	C1, E, H, K	G	M	M	M	E	G	E	P	E	E	E	E	E
30k. Vinyl pyrrolidone	SR, H	A, C1, E, H, K, W	P	P	G	G	G	M	M	G	E	E	E	E	E
30l. Vinylidene chloride copolymer	SR, F	E, K, W	E	G	F	G	E	M	G	M	G	E	E	E	G
31. Waxes, modified	F	H	E	P	P	G	E	M	P	P	P	G	E	E	P
32. Zein	CR, H	A, W	M	G	G	G	G	E	F	P	F	E	E	E	F
	SR	A, W	F	F	G	G	G	G	F	P	F	G	G	G	F

[a] Code for bonding classification: SR = Solvent released (from solution or emulsion); F = Fused by heating; V = Vulcanized; R = Cured at room temperature (70–80°F.); M = Cured at moderate temperature (150–200°F.); H = Cured at elevated temperature (275–310°F.); CR = Chemically reacted.

LIST OF MANUFACTURERS AND SUPPLIERS OF RESINS AND ADHESIVES*

1. Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill. (A)
2. Acryvin Corp. of America, 470 E. 99th St., Brooklyn 36, N.Y. (A)
3. Adhesive Engineering, a Div. of Hiller Aircraft Corp., San Carlos, Calif. (A)
4. Adhesive Products Corp., New York 60, N.Y. (RA)
5. Adhesive Products Inc., Albany 10, Calif. (A)
6. Aero Research, Ltd., Cambridge-Duxford, England (A)
7. Alkydol Laboratories, Inc., Cicero 50, Ill. (RA)
8. Allied Chemical Corp., Plastics and Coal Chemicals Div., 40 Rector St., New York 6, N.Y. (RA)
9. American Cyanamid Co., Plastics and Resins Div., 30 Rockefeller Plaza, New York 20, N.Y. (RA)
10. American Latex Products Corp., Hawthorne, Calif. (A)
11. American Lucoflex Inc., 500 5th Ave., New York 36, N.Y. (A)
12. American-Marietta Co., Adhesive, Resin and Chemical Div., 3400 13th Ave., S.W., Seattle 4, Wash. (RA)
13. American Products Manufacturing Co., New Orleans 18, La. (A)
14. Amoco Chemicals Corp., 910 S. Michigan Ave., Chicago 80, Ill. (R)
15. Angier Adhesives, Div. of Interchemical Corp., 120 Potter St., Cambridge 42, Mass. (A)
16. Arabol Mfg. Co., 110 E. 42nd St., New York 17, N.Y. (A)
17. Archer-Daniels-Midland Co., Minneapolis 2, Minn. (A)
18. Aries Laboratories, Inc., 45-33 Davis St., Long Island City, N.Y. (A)
19. Armour and Co., 1355 W. 31st St., Chicago 9, Ill. (A)
20. Armstrong Cork Co., Lancaster, Pa. (A)
21. Armstrong Products Co., P.O. Box 1, Warsaw, Ind. (A)
22. Atlas Mineral Products Co., Mertztown, Pa. (A)
23. Atlas Powder Co., Wilmington 99, Del. (A)
24. Atlas Synthetics Corp., Long Island City 1, N.Y. (R)
25. Badische Anilin & Soda-Fabrik AG, Ludwigshafen am Rhein, Germany
26. B.B. Chemical Co., 784 Memorial Drive, Cambridge 39, Mass. (A)
27. Belding Corticelli Industries, Chemicals Div., 1407 Broadway, New York 18, N.Y. (R)
28. Biggs Co., Inc., Carl H., Los Angeles 64, Calif. (A)
29. B.I.P. Chemicals Ltd., Tat Bank House, Oldbury, Birmingham, England
30. Blacher, B., 752 Broadway, New York 3, N.Y.
31. Bloomingdale Rubber Co., Aberdeen, Md. (A)
32. Bond Adhesives Co., Box 406, Main P.O., Jersey City 3, N.J. (A)
33. Borden Chemical Co., Div. of The Borden Co., 350 Madison Ave., New York 17, N.Y. (RA)
34. British Resin Products Ltd., London W. 1, England (RA)
35. California Ink Co., Inc., 545 Sansome, San Francisco, Calif.
36. Canadian Industries Ltd., Montreal, Canada (R)
37. Carboline Co., 32 Hanley Ind. Ct., St. Louis 17, Mo. (A)
38. Catalin Corp., 1 Park Avenue, New York 16, N.Y. (RA)
39. Celanese Corp. of America, Plastics Div., 744 Broad St., Newark 5, N.J. (RA)
40. Chemical Coatings and Engineering Co., Inc., Media, Pa. (A)
41. Chemical Development Corp. (Devcon Corp.), Danvers, Mass. (A)
42. Chemical Process Co., 901 Spring St., Redwood City, Calif. (R)
43. Chemical Products Corp., King Philip Rd., E. Providence 14, R.I.
44. Ciba Co., Inc., Plastics Div., Kimberton, Pa. (R)
45. Colton Chemical Co., a Div. of Air Reduction Co., Inc., 1747 Chester Ave., Cleveland 14, Ohio (R)
46. Compo Chemical Co., Inc., Waltham 54, Mass. (A)
47. Cordo Chemical Co., 34 Smith St., Norwalk, Conn. (A)
48. Corn Products Sales Co., Chemical Div., New York 4, N.Y. (A)
49. Cycleweld Cement Products Div., Chrysler Corp., 5437 W. Jefferson, Trenton, Mich. (A)
50. Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo. (A)
51. Dewey and Almy Chemical Co., Div. of W.R. Grace and Co., Cambridge 40, Mass. (A)
52. Dow Chemical Co., The, Midland, Mich. (RA)
53. Dow Corning Corp., Midland, Mich. (RA)
54. Dreyfus Co., L.A., So. Plainfield, N.J. (A)
55. Du Pont de Nemours and Co., E.I., Wilmington 98, Del. (RA)
56. Durez Plastics Div., Hooker Chemical Corp., 888 Walck Rd., North Tonawanda, N.Y. (RA)
57. Eastman Chemical Products, Inc., Kingsport, Tenn. (RA)
58. Emerson and Cuming, Inc., Canton, Mass. (A)
59. Epoxylite Corp., El Monte, Calif. (A)
60. Farrington Texol Corp., Walpole, Mass. (A)
61. Flintkote Co., Atlas Adhesives Div., Philadelphia 27, Pa. (A)
62. Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio (A)
63. Fuller Co., H.B., 255 Eagle St., St. Paul 2, Minn. (A)
64. Furane Plastics Inc., Los Angeles 39, Calif. (RA)
65. General Aniline and Film Corp., New York 14, N.Y. (R)
66. General Electric Co., Pittsfield, Mass. (RA)
67. General Latex and Chemical Corp., Cambridge 39, Mass. (A)
68. General Mills, Inc., Chemical Div., P.O. Box 191, Kankakee, Ill. (RA)
69. Goodrich Industrial Products Co., B.F., 500 S. Main St., Akron 18, Ohio (RA)
70. Goodyear Tire and Rubber Co., Chemical Div., Akron 16, Ohio (A)
71. Gordon-Lacey Chemical Products Co., Maspeth, Long Island, N.Y. (A)
72. Griffin Chemical Co., Div. of Nopco Chemical Co., 1000 16th St., San Francisco 7, Calif. (R)
73. Harwick Standard Chemical Co., Akron 5, Ohio (A)
74. Hercules Powder Co., Wilmington 99, Del. (R)
75. Heresite & Chemical Co., Manitowoc, Wis. (RA)
76. Hewitt and Bros., Inc., C.B., New York 13, N.Y. (A)
77. Homalite Corp., The, Wilmington, Del.
78. Houghton Laboratories, Inc., 322 Bush St., Olean, N.Y. (A)

*(R) = sources of materials for compounding adhesives. (A) = sources of adhesive compositions.

TRADE DESIGNATIONS	MANUFACTURERS OR SUPPLIERS OF RESINS OR ADHESIVES (*See list below for key to numbers*)
30g. Arcco (33), Bakelite (147), Bondmaster (131), Butvar (135), Chem-O-Sol (43), Dennis (50), Farrington (60), Helix (26), Laco (83), Midland (90), Placco (33), Plastibond (71), Plasticweld (85), Plastilock (69), Polybond (118), Reslac (33), Resyn (101), VC (134)	4, 26, 32, 33, 43, 50, 55, 60, 69, 71, 79, 83, 85, 90, 101, 112, 116, 117, 118, 120, 125, 130, 131, 134, 135, 147, 155
30h. Ampcoflex (22), Anodex (69), Arcco (33), Bakelite (147), Bondmaster (131), Bostik (26), BRC (31), CD Cement (41), Compo (46), Cordo-Bond (47), Dennis (50), Fedco (98), Helix (26), Laco (83), Loven (86), Midland (90), Pee Vee Cee (22), Placco (33), Plastibond (71), Plastigrip (4), Plastilock (69), Plastite (115), Polybond (118), Polyco (33), Reslac (33), Resyn (101), Rubbagrip (130), Upaco (148), Vinylgrip (4), Watson-Standard (155)	4, 15, 20, 22, 26, 31, 33, 41, 46, 50, 55, 69, 71, 83, 86, 90, 98, 101, 112, 115, 117, 118, 120, 125, 130, 131, 134, 147, 148, 155
30i. API (5), Arcco (33), Bakelite (147), Bond (32), Bondmaster (131), Bostik (26), CD Cement (41), Compo (46), Cordobond (47), Dennis (50), Fedco (98), Fuller (63), Helix (28), Hewbind (76), Kotol (103), Marvinol (103), Midland (90), Placco (33), Plastibond (71), Plastilock (69), Plastite (115), Pliastic (98), Polybond (118), Polyco (33), Reslac (33), Resyn (101), Rubbagrip (130), Stabond (10), Synco (142), Tygobond (151), Upaco (148), U-Sement (150), VC-2 (134), Vinylgrip (4), Watson-Standard (155), 3 M (92)	4, 5, 10, 15, 16, 20, 26, 28, 32, 33, 41, 46, 47, 50, 55, 63, 69, 71, 76, 79, 81, 90, 92, 98, 101, 103, 112, 115, 116, 117, 118, 120, 125, 130, 131, 134, 142, 147, 148, 150, 151, 155, 156
30j. Propiofan (25)	25
30k. PVP (65), Vinrez (140)	65, 140
30l. Arcco (33), Bondmaster (131), CD Cement (41), Cordo-Bond (47), Dennis (50), Goodrich, B.F. (69), Hu-Rez (79), Midland (90), Miracle (94), Ohio (108), Placco (33), Polybond (118), Polyco (33), Reslac (33), Resyn (101), Rubbagrip (130), Saran (52), Upaco (148), Vinylgrip (4), Watson-Standard (155), 3 M (92)	4, 15, 20, 33, 41, 50, 52, 69, 79, 90, 92, 94, 98, 101, 108, 112, 117, 118, 120, 125, 130, 131, 134, 148, 155
31. API (5), Fuller (63), Indu-Sealz (103), Ladwax (54), Midland (90), Polybond (118), Resimelt (98), Reswax (33), Resyn (101), Upaco (148)	5, 15, 16, 33, 54, 63, 90, 97, 98, 101, 103, 118, 120, 125, 148
32. Arcco (33), Argo (48), Midland (90), Paisley (98), Placco (33), Polybond (118), Reslac (33), Upaco (148)	33, 48, 90, 98, 118, 125, 148

[b] Code for solvents: A = Alcohols; Cl = Chlorinated hydrocarbons; E = Esters; H = Aromatic hydrocarbons; HA = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water (solution or emulsion).

[c] Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair, P = Poor.

LIST OF MANUFACTURERS AND SUPPLIERS OF RESINS AND ADHESIVES* (*Continued*)

79. Hughes Glue Co., Detroit 7, Mich. (A)
80. Imperial Chemical Industries Ltd., London S.W. 1, England (R)
81. Interchemical Corp., Finishes Div., 67 W. 44th St., New York 36, N.Y. (A)
82. Koppers Co., Inc., Chemical Div., Pittsburgh 19, Pa. (RA)
83. Lawrence Adhesive and Chemical Co., Lawrence, Mass. (A)
84. Lebec Chemical Corp., Paramount, Calif. (A)
85. Lithgow Chemical Co., Div. of Reinhold Engineering and Plastics Co., 12827 E. Imperial Highway, Norwalk, Calif.
86. Loven Chemical of California, Newhall, Calif. (RA)
87. Magic Chemical Co., Brockton 2, Mass. (A)
88. Marblette Corp., Long Island City 1, N.Y. (RA)
89. Marbon Chemical Div., Borg-Warner Corp., Gary, Ind. (A)
90. Midland Adhesive and Chemical Corp., Detroit 20, Mich. (A)
91. Minneapolis-Honeywell Regulator Co., 2753 4th Ave. S., Minneapolis 8, Minn.
92. Minnesota Mining and Mfg. Co., Adhesives, Coatings & Sealers Div., 900 Bush Ave., St. Paul 6, Minn. (A)
93. Minnesota Mining and Mfg. Co., Chemical Div., 900 Bush Ave., St. Paul, Minn. (A)
94. Miracle Adhesives Corp., 214 E. 53rd St., New York 22, N.Y. (A)
95. Mobay Chemical Co., St. Louis 4, Mo. (A)
96. Monite Waterproof Glue Co., Minneapolis, Minn.
97. Monsanto Chemical Co., Plastics Div., Springfield 2, Mass., and 911 Western Ave., Seattle 4, Wash. (RA)
98. Morningstar-Paisley, Inc., 630 W. 51st St., New York 19, N.Y. (A)
99. Multiplastics Div., Curd Enterprises, Inc., 3337 Lincoln St., Franklin Park, Ill. (R)
100. Narmco Resins and Coatings Co., Costa Mesa, Calif. (A)
101. National Adhesives Div., National Starch Products Co., 750 Third Ave., New York 17, N.Y. (RA)
102. National Casein Co., 601 W. 80th St., Chicago 20, Ill. (RA)
103. Naugatuck Chemical Div., U.S. Rubber Co., Naugatuck, Conn. (RA)
104. Neville Chemical Co., Neville Island, Pittsburgh 25, Pa. (R)
105. New York Quinine and Chemical Works, Inc., The, 50 Church St., New York 8, N.Y. (R)
106. Nova Chemical Corp., 147 Waverly Pl., New York 14, N.Y. (R)
107. Nureco Inc., Cranston 10, R.I. (RA)
108. Ohio Adhesives Corp., New Philadelphia, Ohio (A)
109. Pennsylvania Industrial Chemical Corp., Clairton, Pa. (R)
110. Perkins Glue Co., Lansdale, Pa. (RA)
111. Philadelphia Quartz Co., Philadelphia 6, Pa. (RA)
112. Pierce and Stevens, Inc., 710 Ohio St., Buffalo 3, N.Y. (A)
113. Pittsburgh Plate Glass Co., Springdale, Pa. (R)
114. Plastics Engineering Co., Sheboygan, Wis. (R)
115. Plastite Adhesives Corp., Chicago 10, Ill. (RA)
116. Poly Resins, Sun Valley, Calif. (R)
117. Polymer Chem. Co., 5920 Carthage Ave., Cincinnati, Ohio (A)
118. Polymer Industries Inc., Springdale, Conn. (A)
119. Polypenco, Inc., Reading, Pa. (A)
120. Pyroxylin Products, Inc., Chicago 32, Ill.; Paoli, Pa. (A)
121. Raffi and Swanson, Inc., Wilmington, Mass. (A)
122. Randolph Products Co., Carlstadt, N.J.
123. Reichhold Chemicals, Inc., White Plains, N.Y. (RA)
124. Ren Plastics Inc., Lansing 4, Mich. (A)
125. Research Sales, Inc., P.O. Box 358, Suffern, N.Y. (A)
126. Reynolds Chemical Products Co., Ann Arbor, Mich. (A)
127. Rezolin, Inc., 1651 18th St., Santa Monica, Calif.
129. Robertson Co., H.H., 2400 Farmers Bank Bldg., Pittsburgh 22, Pa.
129. Rohm & Haas Co., Resinous Products Div., 222 W. Washington Sq., Philadelphia 5, Pa. (RA)
130. Rubba, Inc., 1015 E. 173rd St., New York 60, N.Y. (A)
131. Rubber and Asbestos Corp., Bloomfield, N.J. (A)
132. Rubber Corp. of America, Latex and Chemical Div., New South Rd., Hicksville, L.I., N.Y. (RA)
133. Schenectady Varnish Co., Inc., Schenectady 1, N.Y. (R)
134. Schwartz Chemical Co., Inc., 50-01 Second St., Long Island City 1, N.Y. (A)
135. Shawinigan Products Corp., New York 1, N.Y. (RA)
136. Shell Chemical Corp., New York 20, N.Y. (RA)
137. Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17, N.Y.
138. Slomons Laboratories, Inc., Long Island City 1, N.Y. (A)
139. Stanley Chemical Co., The, Berlin St., East Berlin, Conn.
140. Stein-Hall and Co., Inc., New York 17, N.Y. (A)
141. Swift and Co., 4115 Packers Ave., Chicago 9, Ill. (RA)
142. Synco Resins, Inc., Bethel, Conn. (RA)
143. Synvar Corp., 415 E. Front St., Wilmington 99, Del. (RA)
144. Tylene Plastics, Inc., Freyer Rd., Michigan City, Ind.
145. UBS Chemical Corp., Cambridge 42, Mass. (A)
146. Union Carbide Chemicals Co., Div. Union Carbide Corp., 30 E. 42nd St., New York 17, N.Y.
147. Union Carbide Plastics Co., 30 E. 42nd St., New York 17, N.Y. (RA)
148. Union Paste Co., 1605 Hyde Park Ave., Hyde Park 36, Mass. (A)
149. U.S. Plywood Corp., 55 W. 44th St., New York 18, N.Y. (RA)
150. U.S. Rubber Co., Rockefeller Center, New York 20, N.Y. (RA)
151. U.S. Stoneware Co., 100 Brimfield Rd., Akron 9, Ohio (A)
152. Valite Corp., 726 Whitney Bldg., New Orleans 12, La. (RA)
153. Varcum Chemical Corp., Packard Rd., Niagara Falls, N.Y. (RA)
154. Velsicol Chemical Corp., Chicago 11, Ill. (R)
155. Watson-Standard Co., 225 Galveston Ave., Pittsburgh 30, Pa. (R)
156 Williamson Adhesives, Inc., 8220 Kimball Ave., Skokie, Ill. (A)
157. Xylos Rubber Co., Div. of The Firestone Tire and Rubber Co., Akron 1, Ohio (A)
158. Zinsser and Co., Inc., Wm., New York 19, N.Y. (A)

*(R) = sources of materials for compounding adhesives. (A) = sources of adhesive compositions.

TYPE OF PLASTIC BASE	TRADE DESIGNATIONS OF RESINS OR COATINGS	MANUFACTURERS OR SUPPLIERS OF RESINS OR COATINGS *(See list on pp. 530-31 for key to numbers)*
1. Acrylate and methacrylate	Acri-Flo (90), Acrigrip (2), Acripol (169), Acronal (23), Acrylac (188), Acryloid (174), Acrylon (32), Arcco (32), AT (178), Bedacryl (105), Butakon M (105), Catalin (41), Cordobond (54), Corrocote (45), Coverlac (187), Dennis (58), Duracryl (156), Farrington (75), Gloze (89), Gordon-Lacey (95), Hycryl (197), Inceloid (13), Indusol (107), Kotol (140), Krylon (114), Logo (25), Lucite (65), Lustrasol (169), Lytron (133), MCW (127), Midland (126), Modicol (144), Nubeloid (91), Placco (32, 57), Placquer (57), Polyco (32), Polyflex (108), Polyplex (190), Reslac (32), Resyn (139), Rexton (172), Rez-N-Lac (178), Rhoplex (174), Stanley (189), Ubatol (197), Unichrome (124), Vitrilan (108), 3 M (128)	5, 13, 19, 21, 23, 25, 32, 38, 41, 45, 47, 54, 57, 58, 65, 75, 91, 95, 105, 108, 109, 110, 114, 115, 124, 126, 127, 128, 133, 139, 140, 143, 144, 155, 156, 159, 164, 165, 166, 168, 169, 171, 172, 174, 175, 178, 187, 188, 189, 190, 191, 195, 197, 201, 205
2. Alkyd resins (phthalic anhydride-polyhydric alcohol-oil combinations)	Alkydol (3), Amalite (7), Amberlac (174), Armorcord (18), Aulflex (108), Bar-ox (196), Beckosol (169), B.I.P. (28), Carbosol (148), Cellolyn (100), Crown (56), Duraplex (174), Durez (66), Dyal (184), Epok (36), Falkyd (40), FCD (80), Glyptal (86), Indusol (107), Kotol (140), Logo (25), Lustrasol (169), MCW (127), Mirasol (148), Mol-Rez (132), Nubelite (91), Oxalkyd(208), Paralac (105), Paraplex (174), Plaskon (4), Randolph (168), Rez-N-Lac (178), Rezyl (9), Schenectady (177), Stanley (189), Styresol (169), Sullvar (190), Super-Beckosol (169), Syntex (111), Synthemul (169), Varkyd (123), Wallkyd (169), Waterez (169)	3, 4, 9, 18, 19, 21, 25, 28, 34, 36, 38, 40, 52, 56, 66, 68, 80, 86, 91, 100, 105, 108, 110, 111, 123, 127, 132, 140, 143, 148, 155, 164, 166, 168, 169, 171, 172, 174, 177, 178 184, 188, 189, 190, 195, 196, 201, 205, 207, 210
3. Allyl starch resin		91, 155
4. Asphalts	Arcco (32), Atlastic (22), Lebec (117), Loven (119), Midland (126), Nebony (141), Pioneer (210), Placco (32), Resinex (99), Reslac (32), Transphalt (151), Witcote (209), 3 M (128)	13, 22, 32, 91, 99, 117, 119, 126, 128, 130, 151, 209
5. Cellulose acetate	Acetaplex (190), Arcco (32), CD (46), Cordobond (54), Cymel (9), Dyal (184), Farrington (75), Gordon-Lacey (95), Hercules (100), Inceloid (13), Logo (25), MCW (127), Midland (126), Placco (32), Reslac (32), Rez-N-Lac (178), Unichrome (124)	8, 13, 19, 20, 25, 32, 44, 46, 47, 54, 65, 67, 75, 91, 95, 100, 110, 111, 115, 124, 126, 127, 128, 133, 155, 159, 165, 166, 168, 171, 178, 184, 188, 190, 193, 201
6. Cellulose acetate butyrate	Arcco (32), Butaplex (190), Cordobond (54), Gordon-Lacey (95), Half-Second Butyrate (67), Indusol (107), Lebec (117), Logo (25), MCW (127), Midland (126), Placco (32), Plastrip (163), Reslac (32), Resyn (139), Rez-N-Lac (178), Seal-Peel (179), Stanley (189), Stipgrip (2), Thermo-Cote (29), Thermodip (73), Tool-Dip (158), Westcoat (206)	2, 19, 21, 25, 29, 32, 47, 54, 67, 73, 91, 95, 107, 108, 110, 111, 115, 117, 126, 127, 139, 143, 155, 158, 159, 163, 165, 166, 168, 171, 172, 178, 179, 188, 189, 190, 193, 201, 206
7. Cellulose, carboxymethyl	Carbose (212), Cellofas (105), Hercules CMC (100), Logo (25), Midland (126), Sodium CMC (65)	25, 38, 65, 100, 105, 126, 155, 159, 178, 212
8. Cellulose, ethyl	Compo (51), Ethocel (62), Farrington (75), Gordon-Lacey (95), Hercules (100), Inceloid (13), Indusol (107), Logo (25), MCW (127), Midland (126), Randolph (168), Resyn (139), Rez-N-Lac (178), Seal-Peel (179), Thermo-Cote (29), Tool-Dip (158), Westcoat (206)	13, 19, 21, 25, 29, 47, 51, 62, 75, 91, 95, 100, 107, 108, 110, 115, 126, 127, 139, 143, 155, 158, 159, 165, 166, 168, 171, 172, 178, 179, 201, 206
9. Cellulose, hydroxyethyl	Cellosize (198), Logo (25), Rez-N-Lac (178), Whirlsint (138, 160)	25, 47, 155, 159, 178, 198
10. Cellulose, ethyl hydroxyethyl	EHEC (100), Rez-N-Lac (178)	100, 178
11. Cellulose, methyl	Methocel (62)	62
12. Cellulose nitrate	Arcco (32), Armolac (18), Aultone (108), Blue Knight (108), CD (46), Compo (51), Dennis (58), Farrington (75), Hercules (100), Inceloid (13), Logo (25), MCW (127), Midland (126), Nik-o-lac (143), Placco (32), Reslac (32), Resyn (139), Rexlance (172), Rez-N-Lac (178), Stanley (189)	9, 13, 18, 19, 20, 21, 25, 32, 34, 46, 47, 51, 58, 65, 91, 100, 108, 110, 115, 126, 127, 133, 139, 143, 155, 159, 165, 166, 168, 171, 172, 178, 188, 189, 193, 195
13. Cellulose propionate	Logo (25)	25, 43, 178
14. Cellulosics—special	Corvel (138, 160)	138, 160
15. Chlorinated paraffins	Cereclor (105), Chlorowax (61), Clorafin (100), Halowax (199), Logo (25), Midland (126), Stan-Chlor Oil (99)	25, 38, 61, 91, 99, 100, 102, 105, 111, 126, 155, 171, 199
16. Chlorinated polyether	Corvel (138, 160)	138, 160
17. Chlorinated rubber	Alloprene (105), Apco (2), Arcco (32), Armorcote (18), Carboline (39) Corrocote (45), Dennis (58), Farrington (75), Gordon-Lacey (95), Heresite (101), Laco (116), Lebec (117), Logo (25), MCW (127), Midland (126), Para-Stonetex (196), Paratex (196), Parlon (100), Placco (32), Randolph (168), Resimene (133), Reslac (32), Rexadur (172), Rez-N-Lac (178), Roxaprene (108), Stanley (189), Texkote (158), Vulcabond (11), 3 M (128)	2, 10, 11, 18, 25, 32, 38, 39, 45, 58, 75, 91, 95, 100, 101, 105, 108, 116, 117, 126, 127, 128, 133, 155, 158, 159, 164, 165, 166, 168, 171, 172, 178, 188, 189, 195, 196, 197
18. Coumarone resins	Cumar (4), Durez (66), Epok (36), Inceloid (13), Neville R (141), Nevindene (141), Paradene (141), Piccoumaron (151), Piccovar (151), Velsicol (158)	4, 13, 36, 66, 91, 96, 99, 141, 151, 155, 158, 159, 165, 171, 203
19. Cyclized rubber	Acidseal (93), Alpex (3), Pliolite NR (94)	3, 91, 93, 94, 111, 119, 155, 159, 165
20. Epoxy resins (epichlorohydrin bisphenol resins)	Alk-o-flex (3), Amercoat (5), Araldite (49), Aritemp (17), Armorcoid (18), Bakelite (199), Carboline (39), Cardolite (129), CD (46), Chem-Fast (196), Cordobond (54), Corrocote (45), Corvel (138, 160), Crown (56), DER (62), Devran (59), Dura-Line (186), Duranite (91), Duro-Lok (139), Dyphenite (184), Eccocoat (70), Epi-Kote (83), Epiphen (32), Epi-Rez (111), Epi-Tex (111), Epi-Var (111), Epocast (83), Epolax (116), Epon (183), Eponite (190), Epotuf (169), Epoxin (108), Epoxylite (72), Epoxyn (53), Flawmaster (27), Flexyd (79), Glid-Plate (91), Helix (27), Hi-Bake Sterilkote (34), Hysol (103), Lithgow (118), Logo (25), Loven (119), Maraset (121), MCW (127), Midland (126), Mirasol (148), Narmco (137), Nepoxide (22), Nipoxin (108), Nu-Pon (91), Nu-Pon Cote (91), Nureco (146), Perma-Skin (58), Placquer (57), Poly-Kast (158), Polyox (169), PRC (161), Randac (130), Ren (170), Resiweld (81), Rexclad (172), Rez-N-Lac (178), Schenectady (177), Speedrex (196), Stanley (189), Thoxene (211), Tygon Series E (200), Unichrome (124), 3C-90 (48), 3 M (128)	3, 5, 15, 17, 18, 21, 22, 25, 27, 32, 34, 39, 45, 46, 47, 48, 49, 52, 54, 56, 57, 58, 59, 62, 68, 70, 72, 79, 81, 83, 91, 103, 108, 110, 111, 113, 115, 116, 118, 119, 121, 124, 126, 127, 128, 129, 130, 137, 138, 139, 143, 146, 148, 155, 158, 160, 161, 164, 165, 166, 168, 169, 170, 171, 172, 174, 177, 178, 183, 184, 186, 188, 189, 190, 195, 196, 199, 200, 201, 205, 207, 211
21. "Ester-type" resins-oil reactive (bicycloheptane dicarboxylic acid, and related esters with drying oils)	Pentacite (169), Stanley (189), Synthe-copal (169)	91, 155, 169, 178, 189, 205

[a] Code for solvents: A = Alcohols; C = Chlorinated hydrocarbons; E = Esters; F = Furan; G = Glycols; H = Aromatic hydrocarbons; I = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water emulsions; WA = Aqueous alkali.

DRYING CLASSIFICATION[b]	SOLVENTS OR DISPERSING AGENTS[a]	RESISTANCE RATING[c]								SUITABILITY FOR USE IN COATING[c]										TYPICAL USES OF COATINGS MADE FROM PLASTIC BASE INDICATED ON OPPOSITE PAGE
		Acids	*Alkalies*	*Water*	*Solvents*	*Heat*	*Cold*	*Fungus*	*Weather*	*Metal*	*Paper*	*Fabrics*	*Plastics*	*Wood*	*Leather*	*Ceramics*	*Glass*	*Concrete*	*Wire*	
1. A, B, F	A, C, E, H, K, W	G* *Poor to concentrated acids	G	E	P	E	M	G	E	G* *n-butyl, i-butyl and mixtures	G	G	G	G	G	G	F	G	P	Electrical coatings, fabric treatment, leather finishing, metal and paper coatings, thickening and dispersing media, automotive finishes, coatings for architectural concrete, stucco, and floors
2. A, B, F	H, I, W	M	F	G	G	G	G	M	E	E	G	E	G	E	E	G	G	P	G	Automotive finishes, collapsible tube coatings, electrical insulation, emulsion paints, floor coverings, interior and exterior enamels, household and industrial coatings, metal decorative finishes, printing ink, rubber, water paints
3. A, B, F	A, C, E, H, K, N, W	M	M	M	E	G	G	–	–	G	G	G	–	E	–	G	G	–	–	Overprint varnishes, wood sealer
4. A, B, F	C, H, I	E	E	G	P	F	F	G	E	E	E	–	–	E	–	E	–	E	G	Packaging, pipe coatings, roofing, sealers, sound deadeners, undercoatings for autos
5. A, B, F	A, C, E, H, I, K, N, W	F	F	F	M	M	M	G	M	P	G	M	P	F	F	F	F	P	G	High gloss paper, oil- and grease-resistant papers, wire and wood coatings
6. A, B, F	C, E, I, K, N, (H + A)	F	F	M	F	M	G	G	G	G	G	M	G	G	F	F	P	P	G	Airplane dope, strippable coatings, gel lacquer, cable lacquer, finishes for paper, wood, plastics, and metal. Hot melts
7. A, F	W	F	P	P	E	G	G	M	F	–	G	E	G	–	G	–	P	G	–	Fabric finishing, warp sizing, grease-proofing, thickener
8. A, B, F	A, C, E, F, H, I, K, N	M	E	G	F	G	E	E	M	G	E	E	E	M	E	M	M	G	E	Masking agent, metal strip coating, sizing, packaging, styrene plastics, rubber, gel lacquer, paper lacquer
9. A, F	C, H, W	M	M	P	E	G	G	M	F	–	E	E	G	–	G	G	–	–	–	Color binding agent on fabrics, emulsion stabilizer in latex paints, fabric finishing, warp sizing
10. A, F	A, I, H	M	E	G	P	M	E	E	M	–	E	–	E	–	E	–	–	–	–	Silk screen inks
11. A, F	W	F	P	P	G	G	G	P	–	–	G	E	G	–	E	G	–	G	–	Grease-proofing, thickener
12. A, B, F	A, E, H, I, K, N	G	F	E	F	P	G	G	M	E	E	E	–	E	E	–	–	F	–	Artificial leather, furniture coating, decorative coatings, floor finishes, auto and aircraft finishes, nail polish
13. A, F	A, C, E, H, K, N	F	F	M	F	M	G	G	G	M	G	M	F	G	P	F	M	P	G	Strippable coatings, gel lacquers, glass coatings
14. –	–	F	F	G	F	M	G	G	G	E	–	–	–	–	–	M	M	–	E	Decorative, controlled gloss finishes for metal wire products including furniture, appliances, hardware. General-purpose insulation for metal wire & stampings.
15. A, B, F	C, E, F, H, I, K, N	E	G	F	G	F	G	E	M	E	G	E	E	G	M	F	M	G	G	Flameproofing of textiles, paints, printing inks
16. –	–	E	E	E	E	G	E	E	G	E	–	–	–	–	–	G	G	–	E	Chemical corrosion resistant coatings for metal
17. A, B, F	C, E, H, K	E	E	E	F	F	G	E	G	E	E	G	–	G	–	–	–	E	–	Flame retardant coating, corrosion-resistant metal coatings, inks, soap wrap coatings, traffic paints
18. A, B, F	C, E, H, I, K	E	E	E	P	M	P	G	M	E	G	G	M	E	G	F	F	E	G	Anti-corrosive finishes, bronzing liquids, concrete coatings, marine finishes, printing inks, rubber compounds, pipe coatings, floor and trim varnishes, waterproof coatings, emulsion paints
19. A, B, F	C, H, I	E	E	E	G	M	G	E	E	G	E	–	–	–	–	–	–	E	–	Concrete enamel, corrosion-resistant paint, inks
20. A, B, F	A, E, G, H, I, K, W	E	E	G	E	G	E	E	E	E	G	–	G	E	M	E	E	G	G	Can coatings, corrosion-resistant maintenance coatings, chemical resistant coatings, electrical insulation, product finishes, drum linings, floor varnishes, marine finishes, inks, appliance primers, architectural paints and enamels
21. A, B, F	A, C, E, G, H, I, K, N	F	P	G	G	G	G	–	G	E	E	G	G	E	E	G	G	P	G	Durable paper for packaging, electrical insulation ethyl cellulose lacquers, overprint, shade cloth

Code for drying classification: A = Air drying; B = Baking; F = Force drying 120 - 150°F.
Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair; P = Poor

TYPE OF PLASTIC BASE	TRADE DESIGNATIONS OF RESINS OR COATINGS	MANUFACTURERS OR SUPPLIERS OF RESINS OR COATINGS *(See list on pp. 530-31 for key to numbers)*
22. Ethylene resins (polyethylene) (low- or high-density)	A-C (180), Agilene (6), Alathon (65), Alkathene (105), Bakelite (199), C.I.L. (105), Corvel (138, 160), Dow (62), Dura-Line (186), Dylan (113), Epolene (67), Fortiflex (43), Hi-fax (100), Hostalen (74), Ladcote (64), Logo (25), Lupolen (23), Marlex (154), Modulene (135), Monsanto (130), Resinite (171), Super Dylan (113), Super Modulene (135), Tenite (67), Whirlsint (138, 160)	6, 23, 25, 43, 44, 62, 64, 65, 67, 74, 91, 93, 98, 111, 113, 133, 134, 135, 138, 154, 155, 160, 165, 178, 180, 186, 199
23. Fluoroethylene resins	Agifluor (6), Bakelite (199), Corrocote (45), Exon (76), Fluran (200), Gencote (88), Hostaflon (74), Kel-F (129), Teflon (65)	6, 45, 65, 74, 76, 88, 91, 111, 129, 199, 200
24. Furan resins	Alkor (22), Beckacite (169), Carboline (39), Duralon (200), Durez (66), Dyphene (184), Fura-Tone (129), Jet-Kote (83), Lithgow (118), Loven (119), Resin X (83), Resistojet (83), Tybon (30)	22, 25, 30, 39, 66, 83, 91, 97, 118, 119, 129, 169, 184, 200
25. Hydrocarbon resins (derived from petroleum)	Amercoat (5), Arcco (32), Atlastic (22), Loven (119), Midland (126), Nebony (141), Neville (141), Panarez (14), Piccopale (151), Placco (32), Reslac (32), Velsicol (203), 3 M (128)	5, 14, 22, 32, 34, 91, 99, 119, 126, 128, 141, 151, 155, 165, 171, 203
26. Isobutylene resins (polyisobutylene)	Logo (25), Oppanol B (145), Oppanol B (23), Vistanex (71)	23, 25, 64, 71, 91, 145, 155, 164, 171, 203
27. Ketone resins	Bakelite (199), Corrocote (45)	45, 47, 91, 107, 155, 199, 201
28. Maleic resins	Amberol (174), Arcco (32), Beckacite (169), Carbasol (148), Cellolyn (100), Crown (56), Durez (66), Dyal (184), Dymal (184), Epok (36), Falkote (40), FCD (80), Lewisol (100), Mirasol (148), Pentalyn (100), Petrex (100), Placco (32), Plaskon (4), Reslac (32), Rez-N-Lac (178), Schenectady (177), Stanley (189), Synaryl (3), Syntex (111), Synvar V (191), Teglac (9)	3, 4, 9, 36, 40, 47, 52, 56, 65, 66, 80, 85, 91, 100, 106, 108, 111, 143, 148, 155, 165, 168, 169, 171, 174, 177, 178, 184, 189, 190, 191, 205
29. Melamine resins	B.I.P. (28), Cymel (9), Epok (36), Indusol (107), Logo (25), Plaskon (4), Polymerin (108), Randolph (168), Resimene (133), Rexatherm (172), Rez-N-Lac (178), Stanley (189), Super-Beckamine (169), Synvarol (191), Uformite (174)	4, 9, 25, 28, 36, 47, 68, 91, 107, 108, 133, 143, 155, 165, 168, 169, 171, 172, 174, 177, 178, 184, 189, 191, 201, 205
30. Natural resins (batu, congo copal, damar, elemi, kauri, manila, Sandarac, etc.)	Innes (45), Kopol (169), Schenectady (177), Stanley (189)	80, 91, 106, 143, 165, 169, 171, 177, 189, 205
31. Oleo-resinous materials (combinations of oils, and natural and synthetic resins)	Alkydol (3), Amberlac (174), Armitage (18), Bakelite (199), Beckolin (169), Beckosol (169), Cellolyn (100), Crown (56), Duraplex (174), Durez (66), Dyal (184), Falkyd (40), GE (86), Ladwax (64), Lithgow (118), McCloskey (123), Miravar (148), Mol-Rez (132), Plaskon (4), Resimene (133), Rez-N-Lac (178), Rezyl (9), Schenectady (177), Stanley (189), Sullvar (190), Syntex (111), Synvaren (191)	3, 4, 9, 18, 32, 34, 40, 52, 56, 64, 66, 80, 86, 91, 100, 106, 108, 109, 110, 111, 112, 118, 123, 132, 133, 142, 148, 155, 156, 164, 168, 169, 171, 174, 177, 178, 184, 188, 189, 190, 191, 195, 199, 205, 207, 211
32. Phenol-formaldehyde modified and drying oil combinations (including paraphenylphenolformaldehyde resins and alkylated phenol resins)	Acikote (200), Alkydol (39), Amberol (174), Armitage (18), Bakelite (199), Beckacite (169), Beckopol (169), Bedesol (105), Cardolite (129), Catalin (41), Crown (56), Durez (66), Dyphenite (184), Epok (36), FCD (80), GE (86), Heresite (101), Korez (22), Lamophene (158), Lebec (117), Logo (25), Loven (119), Methylon (86), McCloskey (123), Nevillac (141), Pentalyn (100), Plaskon (4), Plastilock (93), Rez-N-Lac (178), Schenectady (177), Stanley (189), Sullvar (190), Synaryl (3), Syntex (111), Synvarite (191), Varcum (202)	3, 4, 18, 22, 25, 34, 36, 38, 41, 52, 56, 66, 80, 86, 91, 93, 100, 101, 105, 108, 110, 111, 117, 119, 123, 129, 137, 141, 155, 158, 166, 169, 171, 174, 177, 178, 184, 189, 190, 191, 195, 199, 200, 202, 205, 207, 210
33. Phenol-formaldehyde pure resins (spirit-soluble, "heat-reactive" types)	Amberol (174), Amercoat (5), Bakelite (199), Bedesol (105), Carbasol (148), Carboline (39), Catalin (41), Cosmalite (50), Dura-Line (186), Durez (66), Durite (32), Dyphene (184), Epok (36), FCD (80), GE (86), Heresite (101), Kaston (158), Kotol (140), Lebec (117), Lithgow (118), Logo (25), Loven (119), Marblette (121), Methylon (86), Mirasol (148), Plaskon (4), Plenco (157), Plyophen (169), P.Q.L. (140), Resinox (133), Rez-N-Lac (178), Schenectady (177), Stanley (189), Super-Beckacite (169), Synvarite (191), Unichrome (124), Varcum (202), 4 A (108), 4 F (108)	1, 4, 5, 25, 32, 34, 36, 38, 39, 41, 47, 50, 52, 66, 80, 86, 91, 101, 105, 108, 110, 111, 117, 118, 119, 121, 124, 133, 140, 148, 155, 157, 158, 164, 166, 169, 171, 174, 177, 178, 184, 186, 189, 191, 195, 199, 202, 205
34. Polyamide resins	Agrilon (6), Arcco (32), BCI (26), Corrocote (45), Corvel (138, 160), Gordon-Lacey (95), Lithgow (118), Logo (25), Nylam (98), Placco (32), Placquer (57), Plastilock (93), Reslac (32), Versamid (87)	6, 25, 26, 32, 34, 45, 47, 57, 65, 87, 91, 93, 95, 98, 138, 155, 160, 165, 171, 205
35. Polyamide-epoxy resins	Amercoat (5), Aritemp (17), Corrocote (45), Dennis (58), Duranite (91), Duro-Lok (139), Epolac (116), Flexyd (79), Hysol (103), Logo (25), Maraset (121), MCW (127), Midland (126), Narmco (137), Nu-Pon Cote (91), Nureco (146), PRC (161), Rexclad (172), Stanley (189), Vulcabond (11), 3 M (128)	5, 11, 15, 17, 25, 32, 34, 45, 58, 79, 87, 91, 103, 114, 116, 121, 126, 127, 128, 137, 146, 161, 164, 168, 171, 172, 178, 189, 211
36. Polyester resins	Alkydol (3), Amester (7), Ampreg (22), Carboline (39), Cellobond (36), Chemiglas (192), Conolon (137), Daltolac (38), FCD (80), Flexyd (79), GE (86), Glidpol (91), Goodrich, B.F. (93), Hetron (102), IC (108), Isolite (177), Laminal (9), Logo (25), Loven (119), Marco (43), MCW (127), Mol-Rez (132), Nureco (146), Palatol (23), Paraplex (174), Plaskon (4), Polylite (169), Polywood (91), Schenectady (177), Selectron (156), Vibrin (140)	4, 7, 9, 22, 23, 25, 32, 36, 38, 39, 43, 45, 54, 79, 80, 86, 91, 93, 102, 105, 108, 111, 119, 127, 132, 137, 140, 146, 155, 169, 174, 177, 192, 195, 205, 207, 211
— Polyethylene oxide	Polyox (198)	23, 198
37. Polyethylene glycols	Carbowax (198), Chemophor (23), Nopalcols (144)	23, 144, 198
38. Polysulfide-epoxy	Epolac (116), Epoxylite (72), Flexyd (79), Nepoxide (22), Nureco (146), PRC (161), Thiopox (194)	22, 27, 31, 42, 45, 48, 53, 54, 72, 79, 82, 83, 84, 116, 127, 153, 161, 162, 194, 211
39. Rubbers, synthetic 39a. Polychloroprenes	See p. 528 for list of trade designations	a. 2, 15, 22, 25, 32, 39, 45, 51, 58, 65, 79, 91, 93, 111, 116, 119, 126, 128, 137, 155, 159, 161, 164, 186, 197

[a] Code for solvents: A = Alcohols; C = Chlorinated hydrocarbons; E = Esters; F = Furan; G = Glycols; H = Aromatic hydrocarbons; I = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water emulsions; WA = Aqueous alkali.

DRYING CLASSIFICATION[b]	SOLVENTS OR DISPERSING AGENTS[a]	RESISTANCE RATING[c]								SUITABILITY FOR USE IN COATING[c]										TYPICAL USES OF COATINGS MADE FROM PLASTIC BASE INDICATED ON OPPOSITE PAGE
		Acids	*Alkalies*	*Water*	*Solvents*	*Heat*	*Cold*	*Fungus*	*Weather*	*Metal*	*Paper*	*Fabrics*	*Plastics*	*Wood*	*Leather*	*Ceramics*	*Glass*	*Concrete*	*Wire*	
22. N	C,H,I,W (> 60°C.)	E *With stabilizer	E	E	E	G*	E	E	G*	G	E	E	G	P	—	—	—	E	E	Electrical insulation, drum linings, packaging of food, chemicals, and consumer products, hot melt coatings. Pipe wrap and fluidized bed coatings.
23. B	C, W	E	E	E	E	E	E	E	E	E	G	G	—	—	—	E	E	—	E	Drum and tank linings, wire coatings, electrical and corrosion-resistant coatings
24. A, B, F	C, E, H, K	E	E	E	E	E	E	G	E	P	E	M	E	E	M	E	M	E	P	Coatings for wood, concrete, and metal tanks
25. A, B, F	C, E, H, I, N, W	E	E	E	P	M	F	G	M	E	G	G	G	E	G	F	F	E	G	Air-dry and baking enamels, anti-corrosive finishes, bronzing liquids, concrete coatings, floor and trim varnishes, marine finishes, pipe coatings, waterproof coatings
26. —	—	M	F	M	M	G	M	M	M	—	—	—	—	—	—	—	—	—	—	See waxes
27. A, B, C	A, E, F, G, K	G	E	F	M	G	G	G	—	—	—	—	—	—	—	—	—	—	—	Additive to improve adhesion of vinyl and phenolic coatings
28. A, B, F	C, E, H, I, K, N	M	F	M	M	G	M	M	M	G	G	F	F	E	M	F	P	F	F	Floor coverings, furniture lacquers, label coatings, oil cloth, printing inks, tin lithographing, interior enamels
29. B	A, H, I	E	E	G	G	G	G	G	E	E	G	G	G	G	P	E	G	—	G	Automotive coatings, can coatings, refrigerators, textile and leather finishing
30. A, B, F	—	F	F	G	M	M	G	E	F	E	E	—	—	E	G	—	—	G	E	Electrical insulation, floor coatings, lacquers, enamels, varnishes, furniture finishes
31. A, B, F	H, I	G	F	G	F	F	M	F	G	E	M	M	M	G	M	P	P	M	G	Can coating, cap liners, floor varnish, general household finishes, interior and exterior enamels, label coatings, oil cloth, rubbing and furniture varnish, spar varnish
32. A, B, F	A, E, H, K	G	F	E	G	G	G	M	G	E	G	G	G	E	G	E	E	G	E	Can and drum linings, coil varnish, furniture and interior enamels, insulating varnishes, spar, floor concrete, and exterior finishes, wood sealer
33. A, B, F	A, E, H, K, N	E	F	E	E	E	E	E	E	E	E	G	G	G	P	E	G	P	G	Beer cans and drum linings, food cans, food drying equipment, furniture, linings for chemical processing equipment, pipe coatings, rigid structural parts, tank car linings, product finishes
34. A, B, F	Alcohols (>C_2)	M	E	G	G	M	G	E	—	E	E	G	G	E	G	G	G	—	M	Heat sealing foil, labels, packaging papers, printing inks, wire, fabric and paper coating, thixotropic paints, wire tip beads
35. A, B, F	A, H, I, K, W	G	E	E	G	G	E	E	—	E	E	G	E	E	G	E	E	E	E	Can coatings, wire insulation, marine finishes, anti-corrosive finishes, drum linings, pipe linings, chemical resistant coatings
36. A, B, F	H	G	F	G	G	G	G	M	E	E	—	E	—	—	—	—	—	—	E	Electrical insulation, potting compound, concrete, cinderblock, and brick enamels, wood finishing; casting, impregnating fibrous glass
— A	W, few C	P	M	—	E	F	E	E	—	M	G	G	M	M	G	G	F	M	F	Protection against grease, oils, etc.[d]
37. A, F	C, H, W	P	P	P	E	F	F	G	—	F	E	E	E	—	—	P	G	—	F	Anti-fogging coatings for glass, fabric sizing and finishing, paper lubricant, wire drawing
38. A, B, F	H, K, N	G	E	G	E	G	G	G	—	E	E	E	E	E	E	E	E	E	E	Coatings for metal, concrete, wood, and marine surfaces; wire insulation
39. 39a. A, B, F	C, E, H, K, W	E	E	E	E	E	E	E	E	E	E	E	G	G	E	G	G	E	E	

[b] Code for drying classification: A = Air drying; B = Baking; F = Force drying 120–150°F.
[c] Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair; P = Poor; N = None required. [d] Where water susceptibility is not a factor.

TYPE OF PLASTIC BASE	TRADE DESIGNATIONS OF RESINS OR COATINGS	MANUFACTURERS OR SUPPLIERS OF RESINS OR COATINGS *(See list on pp. 530-31 for key to numbers)*
39b. Butadiene-styrene 39c. Butadiene-styrene acrylonitrile 39d. Isoprene-isobutylene 39e. Isoprene-styrene 39f. Polysulfied 39g. Polyacrylic 39h. Polybutadiene 39i. Polyurethane	Acrylon (32), Adprene (2), Ameran (93), Apco (2), Arcco (32), Baytex (197), Butaprene (78), Butakon A (105), Butarez (154), Carboline (39), Chemigum (94), Compo (51), Corrocote (45), Darex (60), Dennis (58), Dura-Line (186), Elprene (22), Enjay Butyl (71), FR-S (77), Gen-Flo (90), Goodrich, B. F. (93), Griptex (2), Herecrol (101), Hycar (92), Kralastic (140), Laco (116), Logo (25), Lotol (140), Loven (119), Marbon (122), Midland (126), Naugapol (140), Naugatex (140), Neelium (14), Neobon (22), Neoprene (65), Nitrex (140), Nu-Fab (2), Paracril (140), Placco (32), Plioflex (94), Polyco (32), PRC (161), Rand (167), Reslac (3), Rhoplex (174), Spraylat (187), Thiokol (194), Thioment (22), Vulcabond (11), 3 M (128)	b. c. 2, 11, 13, 15, 25, 32, 34, 45, 51, 58, 70, 77, 78, 90, 91, 92, 93, 94, 101, 105, 111, 116, 122, 126, 128, 140, 155, 159, 161, 165, 167, 171, 174, 175, 176, 187, 197 d. 25, 32, 71, 91, 111, 155, 159 e. 25, 91, 155, 159 f. 22, 25, 32, 39, 91, 93, 119, 128, 129, 159, 161, 194, 211 g. 32, 91, 92, 111, 155, 159, 197 h. 111, 119, 154 i. 16, 40, 161
40. Shellac	Crown (56), Midland (126)	56, 91, 143, 155, 165, 213
41. Silicone resins	Amercoat (5), Carboline (39), Corrocote (45), DC Silicone Resins (63), G E Silicone (86), Gordon-Lacey (95), Indusol (107), Nubelon (91), Polytherm (108), Stanley (189), Super-Por-Seal (196), Union Carbide (185)	5, 21, 39, 45, 63, 86, 91, 95, 107, 108, 155, 164, 165, 171, 185, 189, 195, 196, 205
42. Silicone-alkyd resins	Dow Corning (63), Dyal (184), FCD (80), Indusol (107), Nubelon (91), Plaskon (4), Schenectady (177), Stanley (189), Syntex (111), Vulcabond (11)	4, 11, 21, 63, 80, 91, 107, 111, 119, 155, 164, 171, 177, 184, 185, 189, 201, 205, 207
43. Silicone-phenolic	Dow Corning (63)	63, 91, 119
44. Silicone rubber	GE (86), PRC (161), Silastic (63), Union Carbide (185)	63, 86, 119, 161, 185
45. Styrene resins (polystyrene)	Arcco (32), Bakelite (199), Calvoseal (118), CD (46), Dow Latex (62), Dylex (113), Inceloid (13), KTPL (113), Ladcote (64), Loxite (78), Lytron (133), Marbon (122), Midland (126), Piccoflex (151), Piccolastic (99, 151), Piccotex (151), Placco (32), Plastaplex (190), Plastiplex (190), Polyco (32), Polystyrolac (188), PS-Resin (62), Resgrip (2), Reslac (32), Rez-N-Lac (178), Stanley (189), Styfil (2), Styroloid (188), Styrophane (188), Ubatol (197)	2, 13, 19, 21, 25, 32, 46, 62, 64, 78, 91, 94, 99, 113, 115, 118, 122, 126, 133, 151, 155, 159, 164, 165, 166, 168, 171, 177, 178, 188, 189, 190, 195, 197, 199
46. Styrene-butadiene resins	Arcco (32), Butaprene (76), Carboline (39), Darex (60), Dow Latex (62), Dylex (113), Gen-Flo (90), Glid-Rez (91), Gordon-Lacey (95), Kralastic (140), Laco (116), Lotol (140), Marbon (122), Midland (126), Placco (32), Pliolite (94), Polyco (32), Polyplex (190), Reslac (32), Rez-N-Lac (178), Zerok (22)	22, 32, 34, 39, 60, 62, 76, 90, 91, 94, 95, 111, 113, 116, 119, 122, 126, 140, 155, 164, 166, 171, 178, 190, 195, 201, 205
47. Styrenated alkyd	Adprene (2), Amapol (7), Alkydol (3), Armorcord (18), Cycopol (9), Dennis (58), Dyal (184), FCD (80), Fosterite (207), Indusol (107), MCW (127), Mol-Rez (132), Plaskon (4), Resimene (133), Schenectady (177), Stanley (189), Styresol (169), Styretex (111)	2, 3, 4, 9, 18, 21, 34, 47, 52, 58, 63, 80, 91, 106, 108, 110, 111, 127, 132, 143, 155, 165, 166, 169, 171, 172, 177, 184, 188, 189, 190, 195, 201, 205, 207
48. Styrenated drying oils	——	3, 52, 91, 155, 171
49. Terpene resins	Indu-sealz (140), Piccolyte (151), Schenectady (177)	91, 99, 140, 151, 155, 165, 171, 177
50. Terpene-phenolics	Crown (56), Duracron (156), Durez (66), Schenectady (177), Super-Beckacite (169), Varcum (202)	56, 66, 91, 111, 169, 171, 177, 202, 205
51. Urea-formaldehyde resins and oil-resin combinations	Amerite (32), Arcco (32), Armorcoid (18), Beckamine (169), Beetle (9), B.I.P. (28), Dyal (184), Epok (36), Fabrez (169), Formaset (204), Ful-O-Mite (81), Lebec (117), Loven (120), Midland (126), Paralac (105), Placco (32), Plaskon (4), Polymerin (108), Randolph (168), Resimene (133), Reslac (32), Rexatherm (172), Stanley (189), Syn-U-Tex (111), Synvarol (191), Uformite (174)	4, 9, 18, 28, 32, 34, 36, 38, 47, 81, 91, 105, 108, 110, 111, 117, 118, 119, 120, 126, 133, 155, 165, 168, 169, 171, 172, 174, 178, 184, 188, 189, 191, 195, 204
52. Urethanes (polyurethanes)	Apocoat (16), Carboline (39), Cargill (40), Charolite (197), Corrocote (45), Daltolac (105), Durathene (156), Goodrich, B. F. (93), Isomelt (177), Lastic (89), Lastic-Kote (89), Mol-Rez (132), Mondur/Multron (131), Pelron (150), PRC (161), Solithane (194), Suprasec (105), Uralane (83)	16, 38, 39, 40, 45, 83, 87, 89, 91, 93, 105, 111, 131, 132, 150, 156, 161, 166, 171, 176, 177, 194, 197, 211
53. Vinyl acetate resins	Acetex (140), Ameran (93), Arcco (32), Bakelite (199), CD (46), Celanese (43), Compo (51), Cordobond (54), Corrocote (45), Crown (56), Darex (60), Dennis (58), Elvacet (65), Epok (36), Everflex (60), Fuller (81), Gelva (182), Goodrich, B. F. (93), Gordon-Lacey (95), Griffco (97), Inceloid (13), Lemac (32), Midland (126), Mowilith (74), Placco (32), Plastigrip (2), Plyamul (169), Polyco (32), Poly-Tex (111), Resgrip (2), Reslac (32), Resyn (139), Rez-N-Lac (178), Seal-Peel (179), Stanley (189), Synvar VE (191), Vinac (50), Vinaplas-Lac (178), Vinymul (134), Wallpol (169)	2, 13, 15, 21, 32, 34, 36, 43, 45, 46, 50, 51, 54, 56, 58, 60, 65, 74, 81, 91, 93, 95, 97, 110, 111, 118, 119, 126, 139, 140, 144, 147, 155, 158, 159, 165, 166, 169, 171, 178, 179, 182, 188, 189, 191, 195, 199
54. Vinyl alcohol	Darex (60), Elvanol (65), Gelvatol (182), Lemol (32), Midland (126), Moviol (74), Resgrip (2), Resyn (139), Vinol (50), 3 M (128)	2, 32, 50, 54, 60, 65, 74, 126, 128 139, 155, 159, 178, 182
55. Vinyl butyral resins	Amercoat (5), Arcco (32), Armorcote (18), Bakelite (199), Butacite (65), Butvar (182), Calvinac (118), Compo (51), Cordobond (54), Corogard (128), Dispersite (140), Goodrich, B. F. (93), Gordon-Lacey (95), Indusol (107), MCW (127), Midland (126), Mowital (74), Perma-Skin (58), Placco (32), Protectophene (158), Rand (167), Reslac (32), Spraylat (187), Stanley (189), Ucilon (124), Unichrome (124), Vy King (59)	5, 18, 21, 32, 34, 47, 51, 54, 58, 59, 65, 74, 91, 93, 95, 107, 111, 115, 118, 119, 124, 126, 127, 128, 140, 155, 158, 159, 165, 166, 167, 168, 171, 172, 178, 182, 187, 189, 195, 199, 201, 205
56. Vinyl chloride resins	Ace-Flex (10), Ameran (93), Amercoat (5), Ampcoflex (22), Arcco (32), Armosol (18), Associated Rubber (20), Avaloid (110), Bakelite (199), Breon (35), Calvinac (118), CD (46), Chemiflex (192), Chem-O-Sol (47), Compo (51), Cordobond (54), Corrocote (45), Corvel (138, 160), Corvic (105), Cyclon (136), Diamond PVC (61), Dow Latex (62), Exon (76), Farrington (75), Firestone Latex (76), Geon (92), Goodrich, B. F. (93), Gordon Lacey (95), Hostalit (74), Inceloid (13), Indusol (107), Kotol (140), Lutofan (23), Marvinol (140), Miccrosol (125), Midland (126), Morpasol (134), Opalon (133), Osco (147), Parcloid (149), Pee Vee Cee (22), Peel-Kote (136), Perma-Skin (58), Placco (32), Plastrip (163), Pliovic (94), Polyco (32), Polyprene (108), P-T-I (163), Randcote (149), Resinite (33), Reslac (32), Resyn (139), Reynosol (173), Seal-Peel (179), Spraypeel (73), Stanley (189), Sterilkote (34), Tool-Dip (158), Tygon (200), Vichrome (108), Vinaplas Lac (178), Vinaplex (190), Vinrex (172), Vinyl Grip (2), Vygen (90), Vy King (111), Westoflex (206), Wilflex (79), Welvic (105)	2, 10, 12, 13, 15, 18, 20, 21, 23, 32, 33, 34, 35, 45, 46, 47, 51, 54, 58, 61, 62, 68, 69, 73, 74, 75, 76, 79, 90, 91, 92, 93, 94, 95, 105, 107, 108, 110, 111, 115, 118, 119, 125, 126, 133, 134, 136, 138, 139, 140, 147, 149, 155, 158, 159, 160, 163, 165, 166, 167, 171, 172, 173, 175, 176, 178, 179, 181, 186, 188, 189, 190, 192, 195, 199, 200, 201, 205, 206

[a] Code for solvents: A = Alcohols; C = Chlorinated hydrocarbons; E = Esters; F = Furan; G = Glycols; H = Aromatic hydrocarbons; I = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water emulsions; WA = Aqueous alkali.

DRYING CLASSIFICATION[b]	SOLVENTS OR DISPERSING AGENTS[a]	RESISTANCE RATING[c]								SUITABILITY FOR USE IN COATING[c]										TYPICAL USES OF COATINGS MADE FROM PLASTIC BASE INDICATED ON OPPOSITE PAGE
		Acids	*Alkalies*	*Water*	*Solvents*	*Heat*	*Cold*	*Fungus*	*Weather*	*Metal*	*Paper*	*Fabrics*	*Plastics*	*Wood*	*Leather*	*Ceramics*	*Glass*	*Concrete*	*Wire*	
39b. A, B F	C, E, H, K, N, W	E	E	E	F	G	E	G	E	E	G	G	G	G	–	G	–	G	E	Concrete paint, electrical insulation and jackets, emulsion paints, floor covering, leather finish, linings for chemical equipment, paper coatings, protective coatings for pipes, valves, tanks, plating racks, wire products, fans, pumps, and electroplating equipment. Textile coatings. Protective coatings for rubber (e.g. tires, heater and brake hose, radiators, ignition wires, etc.)
39c. A, B, F	C, H, K, W	E	E	E	G	E	E	E	E	G	E	E	G	G	E	G	–	G	E	
39d. A, B, F	C, H, I	G	E	E	G	E	G	G	G	–	–	E	–	–	–	–	–	–	E	
39e. A, B, F	C, E, H, I, K, N	E	E	E	F	F	F	E	G	E	G	G	P	E	F	E	E	E	G	
39f. A	C, H, K, W	F	G	G	E	M	G	–	G	G	G	G	–	G	G	–	–	G	–	
39g. ——	C, E, H, K	F	F	F	G	E	F	G	E	G	E	E	–	E	E	–	–	–	E	
39h. A, B	——	–	–	–	E	E	–	–	–	–	–	–	–	–	–	–	–	–	–	Modifying agent for drying oils
39i. A, B, F	A, E, H, I, K	G	M	E	E	G	G	G	E	G	F	F	M	E	G	G	G	G	P	Corrosion-resistant coatings, primers, enamels, potting and molding compounds
40. A	A	F	F	M	F	M	G	E	F	E	E	E	E	E	E	E	E	E	E	Electrical insulation, floor varnish, leather dressings, wood sealer
41. A, B	C, E, H, I, K	G	G	E	F	E	E	E	E	E	–	G	P	–	–	E	E	G	G	Electrical insulation, heat resistant coatings, waterproof treatments, glass sizing for laminating
42. A, B	E, H, I, K	E	G	E	G	E	E	–	E	E	E	E	E	E	E	E	E	–	G	Heat resistant coatings, chalk-resistant maintenance paints, alkali-resistant enamels
43. A, B	E, H, I, K	G	G	E	G	E	F	–	E	E	–	–	E	E	E	E	E	G	G	Weather and water resistant finishes, maintenance paints
44. B	C, H, I	G	M	E	P	E	E	E	E	G	–	E	–	–	–	E	E	–	G	Calking, coating asbestos paper, coating glass fabrics, gaskets, insulating sealants, electrical potting compounds
45. A, B, F	C, E, H, K, N, W	E	E	E	P	F	F	E	G	M	G	E	P	F	E	P	P	E	P	Adhesive sizing, concrete enamels, delustering, detackifier, electric insulation, finishing, stiffening, glass coating, label varnish, leather finish, solvent coating, rubber compounding, floor wax finishes
46. A, B, F	C, H, I, K, W	E	E	E	G	G	E	E	E	E	E	E	–	G	G	–	–	E	E	Concrete enamels, corrosion-resistant paints, interior-exterior latex paints, fabric coatings and sizings, paper coatings, rubber compounding
47. A, B, F	H, I	F	G	G	G	G	M	–	E	E	G	G	–	E	–	–	G	–	–	Decorative coatings, decorative over-finishes, electrical insulation, furniture, high gloss paper, toys
48. A, B, F	H, I	M	G	G	P	G	G	–	–	E	G	E	G	E	E	–	G	F	–	Interior and exterior paints
49. A	C, H, I, N, W	E	E	E	P	G	F	E	M	M	G	G	F	G	G	F	F	E	F	Hot melts, laminating, rubber compounding, sealing, waterproofing
50. A	C, E, H, I	M	G	E	F	G	G	E	–	E	–	G	E	E	G	–	–	G	E	Architectural finishes, exterior fabrics (canvas), floor covering, industrial finishes, metal furniture, printing inks
51. B, F	A, H	E	E	E	G	G	G	–	G	E	G	M	G	E	P	E	G	–	G	Automobiles, cap liners, collapsible tube coatings, furniture lacquers, kitchen and hospital equipment, refrigerators, textile finishing, venetian blinds
52. A, B, F	E, H, K	G	G	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	Anti-corrosive, solvent-resistant finishes, abrasion and impact resistant finishes, high dielectric coatings, solderable wire enamels, high-gloss marine finishes, flexible rubber coatings, tank linings, concrete floor paints, aircraft finishes, potting and molding compounds
53. A, F	A, C, E, F, H, K N, W, WA	M	M	G	P	M	M	E	G	G	E	E	G	E	G	G	G	E	–	Decorative, fabric finishing, greaseproofing, heat sealing, intaglio inks, leather finish, pigmented and gloss paper coatings, exterior and interior paints
54. A, F	W	P	P	P	E	G	G	G	F	E	E	E	–	–	E	M	–	–	–	Emulsifying, thickening, greaseproofing
55. A, B, F	A, E	M	G	G	M	G	E	G	G	E	–	E	–	E	–	–	E	–	–	Adhesives, foil packaging, impregnating, upholstery, anticorrosive primers, can linings, drum coatings, wood sealers, strip coatings
56. A, B, F	C, E, F, H, I, K, N, W	E	E	E	F	G	G	E	G	E	E	E	P	P	G	P	P	P	E	Concrete vats and piping, electrical insulation, fabric and paper coatings, food packaging, greaseproofing, lining plating baths, strippable coatings, anti-corrosive maintenance coatings, decorative coatings, drum linings, product finishes, heat castings

[b] Code for drying classification: A = Air drying; B = Baking; F = Force drying 120-150° F.
[c] Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair; P = Poor.

TYPE OF PLASTIC BASE	TRADE DESIGNATIONS OF RESINS OR COATINGS	MANUFACTURERS OR SUPPLIERS OF RESINS OR COATINGS *(See list below for key to numbers)*
57. Vinyl chloride-acetate resins (higher chloride types)	Airstrip (158), Ameran (93), Amercoat (5), Arcco (32), Armorhide (18), Avabid (110), Bakelite (199), Breon (35), Carboline (39), CD (46), Compo (51), Cordobond (54), Corogard (128), Corrocote (45), Corvic (105), Coverlac (187), Duraline (186), Exon (76), Farrington (75), Flexbond (50), Gordon-Lacey (95), Hostalit (74), Inceloid (13), MCW (127), Metagrip (2), Midland (126), Nubelyn (91), No. 210 Sealer (89), Parcloid (149), Perma-Skin (58), Placco (32), Plastrip (163), Polyco (32), Rand (167), Reslac (32), Resyn (139), Reynosol (173), Stanley (189), Tygon (200), Ucilon (124), Unichrome (124), Vinaplas-Lac (178), Vulcabond (11), Vy King (59), Wilflex (79), Zerok (22)	2, 5, 11, 13, 15, 18, 21, 22, 32, 34, 35, 39, 45, 46, 47, 50, 51, 54, 58, 59, 74, 75, 76, 79, 83, 91, 93, 95, 105, 107, 110, 111, 115, 118, 119, 124, 126, 127, 128, 139, 149, 155, 158, 159, 163, 164, 165, 166, 167, 171 173, 178, 186, 187, 189, 195, 199, 200, 201, 205
58. Vinyl chloride-vinylidene chloride copolymers	Ameran (93), Amercoat (5), Arcco (32), Avaloid (110), Breon (35), Carboline (39), Corogard (128), Corrocote (45), Diofan (23), Duraline (186), Geon (92), Goodrich, B. F. (93), Inceloid (13), Indusol (107), Midland (126), Perma-Skin (58), Placco (32), Polyco (32), Rand (167), Reslac (32), Resyn (139), Reynosol (173), Saran (62), Seal-Peel (18), Vinaplas-Lac (178), Vinol (50), Wilflex (79)	5, 13, 15, 23, 32, 34, 35, 39, 45, 47, 50, 58, 62, 65, 79, 91, 92, 93, 107, 110, 111, 119, 126, 139, 155, 159, 163, 165, 166, 167, 171, 173, 178, 179, 186, 195, 205
59. Vinyl ether resin	Lutonal (23), Oppanol C (23, 145), PVI (85), PVM (85), Prestix (2)	2, 15, 23, 85, 145, 171
60. Vinyl formal resins	Formvar (182)	91, 111, 178, 182
61. Vinyl pyrrolidone resin	PVP (85)	23, 85
62. Vinylidene chloride — acrylonitrile resins	Arcco (32), Corogard (128), Diofan (23), Dura-Line (186), Goodrich, B. F. (93), Placco (32), Reslac (32), Resyn (139), Saran (62), Vulcabond (11)	10, 11, 23, 25, 32, 62, 91, 93, 111, 128, 139, 155, 165, 171, 186
63. Waxes (paraffin, microcrystalline, etc.)	Aristowax (152), Ladwax (64), Mekon (204), Multiwax (152), Reswax (32), Unichrome (124), Warco (204)	11, 15, 32, 64, 65, 91, 111, 124, 130, 152, 165, 204
64. Zein (soluble protein)	Argo (55)	55, 165

[a] Code for solvents: A = Alcohols; C = Chlorinated hydrocarbons; E = Esters; F = Furan; G = Glycols; H = Aromatic hydrocarbons; I = Aliphatic hydrocarbons; K = Ketones; N = Nitrohydrocarbons; W = Water emulsions; WA = Aqueous alkali.

LIST OF MANUFACTURERS AND SUPPLIERS OF COATINGS AND RESINS FOR COATINGS*

1. Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill. (C)
2. Adhesive Products Corp., 1660 Boone Ave., New York 60, N.Y. (C)
3. Alkydol Laboratories, Inc., 3242 S. 50th Ave., Cicero 50, Ill. (R)
4. Allied Chemical Corp., Plastics and Coal Chemicals Div., 40 Rector St., New York 6, N.Y.
5. Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif. (C)
6. American Agile Corp., P.O. Box 168, Bedford, Ohio (C)
7. American Alkyd Industries, Broad and 14th Sts., Carlstadt, N.J. (C)
8. American-British Chemical Supplies, Inc., 180 Madison Ave., New York 16, N.Y. (R)
9. American Cyanamid Co. 30 Rockefeller Plaza, N.Y. 20, N.Y. (R)
10. American Hard Rubber Co., New York 13, N.Y. (C)
11. American Latex Products Corp., Hawthorne, Calif. (C)
12. American Lucoflex Inc., 500 5th Ave., New York 36, N.Y. (C)
13. American Products Manufacturing Co., New Orleans, La. (C)
14. Amoco Chemicals Corp., Chicago 80, Ill. (R)
15. Angier Adhesives, Div. of Interchemical Corp., 120 Potter St., Cambridge 42, Mass. (C)
16. Applied Plastics Co., Inc., 130 Penn St., El Segundo, Calif.
17. Aries Laboratories, Inc., 45-33 Davis St., Long Island City, N.Y. (C)
18. Armitage and Co., John L., 245 Thomas St., Newark 5, N.J. (C)
19. Arrow Lacquer Corp., 208 Dupont St., Brooklyn 22, N.Y. (C)
20. Associated Rubber & Plastic Corp., Bronx 51, N.Y.
21. Atlas Coatings Corp., Long Island City 1, N.Y. (C)
22. Atlas Mineral Products Co., Mertztown, Pa. (C)
23. Badische Anilin & Soda-Fabrik AG, Ludwigshafen am Rhein, Germany
24. B.B. Chemical Co., Cambridge, Mass.
25. Bee Chemical Co., Logo, Inc., Div., 2933 South Stony Island Ave., Chicago 33, Ill. (C)
26. Belding Corticelli Industries, Chemicals Div., 1407 Broadway, New York 18, N.Y. (C)
27. Biggs Co., Inc., Carl H., Los Angeles 64, Calif. (C)
28. B.I.P. Chemicals, Ltd., Tat Bank House, Oldbury, Birmingham, Eng.
29. Bischoff Chemical Corp., Ivoryton, Conn. (C)
30. Booty Resineers, Inc., 112 Jefferson St., Newark, Ohio (C)
31. Boray Mfg. Co., 11434 S. Downey Ave., Downey, Calif.
32. Borden Chemical Co., The, Div. of The Borden Co., 350 Madison Ave., New York 17, N.Y. (R,C)
33. Borden Chemical Co., The, Resinite Dept., Santa Barbara, Calif., and No. Andover, Mass. (R)
34. Bradley and Vrooman Co., 2629 S. Dearborn St., Chicago 16, Ill. (C)
35. British Geon Ltd. London W. 1, England (R)
36. British Resin Products Ltd., London W. 1, England (R)
37. Brutier Products Co., Inc., Secaucus, N.J.
38. Canadian Industries Ltd., Montreal, Que., Canada (R)
39. Carboline Co., 32 Hanley Ind. Ct., St. Louis 17, Mo. (C)
40. Cargill, Inc., Vegetable Oil Div., 200 Grain Exchange, Minneapolis 15, Minn. (R,C)
41. Catalin Corp. of America, 1 Park Ave., New York 16, N.Y.
42. Ceilcote Co., 4832 Ridge Road, Cleveland 9, Ohio (C)
43. Celanese Corp. of America, Plastics Div., 744 Broad St., Newark 5, N.J. (R,C)
44. Celanese Corp. of America, Textile Div., P.O. Box 1414, Charlotte, N.C. (R)
45. Chemical Coatings and Engineering Corp., 211 Brook St., Media, Pa. (C)
46. Chemical Development Corp., Danvers, Mass. (C)
47. Chemical Products Corp., E. Providence 14, R.I. (C)
48. Churchill Chemical Corp., 3137 E. 26th St., Los Angeles, Calif.
49. Ciba Co., Inc., Plastics Div., Kimberton, Pa. (R)
50. Colton Chemical Co., Div. Air Reduction Co., 1747 Chester Ave., Cleveland 14, Ohio (R)
51. Compo Chemical Co., Inc., Boston 54, Mass. (C)
52. Cook Paint & Varnish Co., P.O. Box 389, Kansas City, Mo. (C)
53. Copolymer Chemicals, Inc., 12350 Merriman Road, Livonia, Mich. (C)
54. Cordo Chemical Inc., 34 Smith St., Norwalk, Conn. (C)
55. Corn Products Sales Co., New York 4, N.Y. (R)
56. Crownoil Chemical Co., Inc., Long Island City 1, N.Y. (R)
57. Custom Coatings Co., Los Angeles 34, Calif. (C)
58. Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo. (C)
59. Devoe & Reynolds Co., Inc., P.O. Box 328, Louisville 1, Ky. (C)
60. Dewey and Almy Chemical Co., Div. of W.R. Grace and Co., Cambridge 40, Mass. (R)
61. Diamond Alkali Co., Cleveland 14, Ohio (R)
62. Dow Chemical Co., The, Midland, Mich. (R)
63. Dow Corning Corp., Midland, Mich. (R)
64. L.A. Dreyfus Co., S. Plainfield, N.J. (C)
65. E.I. du Pont de Nemours and Co., (Inc.), Wilmington 98, Del. (R, C)
66. Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N.Y. (R)
67. Eastman Chemical Products, Inc., Kingsport, Tenn. (R)
68. Electro-Technical Products Div., Sun Chemical Corp., 113 E. Centre St., Nutley 10, N.J. (C)
69. Elm Coated Fabrics Co., 261 Fifth Ave., New York 16, N.Y. (C)
70. Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.
71. Enjay Co., Inc., 15 W. 51st St., New York 19, N.Y. (R)
72. Epoxylite Corp., 10829 E. Central Ave., El Monte, Calif. (C)
73. Eronel Industries, 12607 Cerise Ave., Hawthorne, Calif. (C)
74. Farbwerke Hoechst AG, vormals Meister Lubigs & Bruning, FFm, Hoechst, Germany
75. Farrington Texol Corp., 2000 Main St., Walpole, Mass. (C)
76. Firestone Plastics Co., P.O. Box 690, Pottstown, Pa. (R)
77. Firestone Synthetic Rubber & Latex Co., 481 W. Wilbeth Rd., Akron, Ohio
78. Firestone Tire and Rubber Co., Akron, Ohio (R)
79. Flexible Products Co., P.O. Box 306, Marietta, Ga. (C)
80. France, Campbell and Darling, Inc., Kenilworth, N.J. (R)
81. Fuller Co., H.B., St. Paul 2, Minn. (C)
82. Fuller and Co., W.P., P.O. Box 3727, Los Angeles 54, Calif. (C)
83. Furane Plastics, Inc., 4516 Brazil St., Los Angeles, Calif. (R, C)
84. Garland Co., 3800 E. 91st St., Cleveland, Ohio (C)
85. General Aniline and Film Corp., New York 14, N.Y. (R)
86. General Electric Co., 1 Plastics Ave., Pittsfield, Mass. (R)
87. General Mills, Inc., Chemical Div., P.O. Box 191, Kankakee, Ill. (R, C)
88. General Plastics Corp., 1400 N. Washington, Marion, Ind.
89. General Plastics Mfg. Co., 3481 S. 35th St., Tacoma 9, Wash.
90. General Tire and Rubber Co., The, Akron 9, Ohio (R)
91. Glidden Co., 900 Union Commerce Bldg., Cleveland 14, Ohio (C)
92. B.F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio (R)
93. B.F. Goodrich Co., Industrial Products Div., Akron 8, Ohio (C)
94. Goodyear Tire and Rubber Co., Inc., Chemical Div., Akron, Ohio (R)
95. Gordon-Lacey Chemical Products Co., 57-02 48th St., Maspeth 78, N.Y. (C)
96. Grand Rapids Varnish Corp., Grand Rapids 2, Mich. (C)
97. Griffin Chemical Co., Div. of Nopco Chemical Co., 1141 S. 14th St., Richmond, Calif.
98. H & R Industries, 344 E. Walnut St., Nazareth, Pa. (C)
99. Harwick Standard Chemical Co., Akron 5, Ohio (R)
100. Hercules Powder Co., Wilmington 99, Del. (R)
101. Heresite and Chemical Co., 822 S. 14th St., Manitowoc, Wis. (C)
102. Hooker Electrochemical Co., Niagara Falls, N.Y. (R)
103. Houghton Laboratories, Inc. Olean, N.Y. (R, C)
104. Hyben Plastic Fabrics, Inc., 201 E. 146th St., New York 51, N.Y.
105. Imperial Chemical Industries Ltd., London S.W. 1, England (R)
106. O.G. Innes Corp., 10 East 40th St., N.Y. 16, N.Y. (R)
107. Industrial Solvents & Chemicals, Inc., Wilkonsville, Mass.

*This chart includes information on sources of film-forming materials for compounding protective coatings, indicated by (R), and sources of protective coatings prepared from the film-forming materials, indicated by (C). Compounding usually involves the addition of water or organic solvents, plasticizers, colorants, defoamers, detackifiers, thickeners, antioxidants, stabilizers, etc.

DRYING CLASSIFICATION[b]	SOLVENTS OR DISPERSING AGENTS[a]	RESISTANCE RATING[c]								SUITABILITY FOR USE IN COATING[c]										TYPICAL USES OF COATINGS MADE FROM PLASTIC BASE INDICATED ON OPPOSITE PAGE
		Acids	*Alkalies*	*Water*	*Solvents*	*Heat*	*Cold*	*Fungus*	*Weather*	*Metal*	*Paper*	*Fabrics*	*Plastics*	*Wood*	*Leather*	*Ceramics*	*Glass*	*Concrete*	*Wire*	
57. A, B, F	A, E, F, H, I, K, N, W	E	E	E	F	G	G	E	G	E	E	E	P	P	E	P	P	E	E	Collapsible tube coatings, fabric and paper treatments, lining storage tanks, protection of steel against weathering and corrosion, strippable packaging, wire coating, automobile sealers, decorative coatings, drum linings, product finishes
58. A, B, F	C, E, F, H, K, W	E	E	E	E	E	G	E	G	G	E	E	E	G	E	–	–	G	G	Food packaging, greaseproofing paper, finishes, strippable packaging
59. A, B, F	A, C, E, H, K, N, W	P	P	P	P	F	G	G	G	G	G	G	G	G	G	G	G	G	–	Additive in chlorinated rubber paints
60. A, B, F	A, C, F, H, N	M	G	G	G	G	E	G	G	E	–	–	–	E	–	–	–	–	E	Wire coating, can linings, drum coatings, anti-corrosive primers
61. A, B, F	A, C, G, H, K, N, W	P	P	P	P	G	G	G	F	M	E	E	G	M	E	E	E	–	–	Dispersing and emulsifying agent, glass coatings, inks, leveling pigment
62. F	K, W,	E	M	E	E	P	F	E	E	M	E	G	P	P	F	P	P	F	M	Artificial leather, cap liner, chemical resistance, greaseproofing paper
63. ——	H, I, N	E	E	E	–	–	F	G	–	G	E	E	G	G	M	M	G	E	F	Paper coatings for food packaging, beverage containers, cheese wrappers, collapsible tubes, laminated paper
64. A, F	A, C, G, W, WA	F	P	M	G	G	M	F	–	G	E	E	M	E	G	G	F	E	F	Cork binding, greaseproofing, pharmaceutical tablet coating

[b] Code for drying classification: A = Air drying; B = Baking; F = Force drying 120-150° F.
[c] Code for rating: E = Excellent; G = Good; M = Moderate; F = Fair; P = Poor

LIST OF MANUFACTURERS AND SUPPLIERS OF COATINGS AND RESINS FOR COATINGS* *(Cont.)*

108. Interchemical Corp., Finishes Div., 67 W. 44th St., N.Y., N.Y. (C)
109. Irvin, Jewell, and Winson Co., 17 E. 3rd St., Dayton, Ohio (C)
110. Jamestown Finishes Inc., Jamestown, N.Y. (C)
111. Jones-Dabney Co., 1481 S. 11th St., Louisville 8, Ky. (R, C)
112. Keystone Refining Co., Philadelphia 37, Pa. (C)
113. Koppers Co., Inc., Chemical Div., Pittsburgh 19, Pa. (R)
114. Krylon, Inc., Norristown, Pa. (C)
115. Lacquer Specialties, Inc., 249 Ave. P, Newark 5, N.J.
116. Lawrence Adhesives and Chemical Co., Lawrence, Mass. (C)
117. Lebec Chemical Corp., 14066 S. Garfield Ave., Paramount, Calif. (C)
118. Lithgow Chemicals Co., Div. of Reinhold Engineering and Plastics Co., 12827 E. Imperial Highway, Norwalk, Calif. (C)
119. Loven Chemical of California, Newhall, Calif. (R, C)
120. Magic Chemical Co., Brockton, Mass.
121. Marblette Corp., 37-21 30th St., Long Island City, N.Y. (R)
122. Marbon Chemical Div., Borg-Warner Corp., Gary, Ind. (R)
123. McCloskey Varnish Co., 7600 State Rd., Philadelphia 36, Pa. (C)
124. Metal & Thermit Corp., Rahway, N.J. (R)
125. Michigan Chrome and Chemical Co., Detroit 13, Mich. (C)
126. Midland Adhesive and Chemical Corp., Detroit 20, Mich. (C)
127. Midwestern Color Works, 3134 California St., N.E., Minneapolis 13, Minn. (C)
128. Minnesota Mining and Manufacturing Co., Adhesives, Coatings, & Sealers Div., 900 Bush Ave., St. Paul, Minn. (C)
129. Minnesota Mining & Mfg. Co., Chemical Div., 900 Bush Ave., St. Paul 1, Minn. (R)
130. Mitchell Rand Mfg. Corp., 51 Murray St., New York 7, N.Y. (C)
131. Mobay Chemical Co., Pittsburgh 34, Pa. (R)
132. Mol-Rez Div., American Petrochemical Corp., 3134 California St., N.E., Minneapolis 18, Minn.
133. Monsanto Chemical Co., Plastics Div., Springfield 2, Mass. (R)
134. Morningstar-Paisley, Inc., 630 W. 51st St., N.Y. 19, N.Y. (C)
135. Muehlstein, H., and Co., Inc., New York 17, N.Y. (R)
136. Munray Products, Inc., Cleveland 11, Ohio (C)
137. Narmco Resins and Coatings Co., 600 Victoria St., Costa Mesa, Calif. (C)
138. National Polymer Products, Inc., 125 N. Fourth St., Reading, Pa. (C)
139. National Starch Products Inc., Resin Div., 750 Third Ave., New York 17, N.Y. (R, C)
140. Naugatuck Chemical Div., U.S. Rubber Co., Elm St., Naugatuck, Conn. (R, C)
141. Neville Chemical Co., Pittsburgh 25, Pa. (R)
142. Newport Industries Co., Div. of Heyden Newport Chemical Corp., 342 Madison Ave., New York 17, N.Y. (R)
143. Nikolas and Co., Inc., G.J., Bellwood, Ill. (C)
144. Nopco Chemical Co., Inc., 60 Park Place, Newark 1, N.J. (R)
145. Nova Chemical Corp., New York 14, N.Y. (C)
146. Nureco, Inc., 1100 Pontiac Ave., Cranston 10, R.I. (C)
147. Ohio Sealer and Chemical Corp., 2019 S. Broadway, Dayton 9, Ohio (C)
148. Osborn Co., C.J., 1301 W. Blancke St., Linden, N.J. (R)
149. Parcloid Chemical Co., 31 Cross St., Midland Park, N.J. (C)
150. Pelron Corp., 7847 W. 47th St., Lyons, Ill. (C)
151. Pennsylvania Industrial Chemical Corp., Clairton, Pa. (R)
152. Petroleum Specialties, Inc., New York 17, N.Y. (R)
153. Phelon-Faust, 1416 Loughborough Ave., St. Louis, Mo.
154. Phillips Chemical Co., Bartlesville, Okla. (R)
155. Pierce and Stevens Chemical Corp., 710 Ohio St., Buffalo 3, N.Y. (C)
156. Pittsburgh Plate Glass Co., Springdale, Pa. (C)
157. Plastics Engineering Co., 1607 Geele Ave., Sheboygan, Wis. (R)
158. Poly Resins, Sun Valley, Calif. (C)
159. Polymer Chemical Co., Cincinnati 12, Ohio (C)
160. Polypenco, Inc., 2150 Fairmount Ave., Reading, Pa. (C)
161. Products Research Co., 3126 Los Feliz Blvd., Los Angeles 39, Calif.
162. Products Research Service, Inc., New Orleans, La.
163. Protective Treatments, Inc., 420 Dellrose Ave., Dayton 3, Ohio (C)
164. Prufcoat Laboratories, Inc., Cambridge 42, Mass. (C)
165. Pyroxylin Products, Inc., Chicago 32, Ill. (C)
166. Raffi and Swanson, Inc., Wilmington, Mass. (C)
167. Rand Rubber Co., Brooklyn 16, N.Y. (R)
168. Randolph Products Co., Carlstadt, N.J. (C)
169. Reichhold Chemicals, Inc., White Plains, N.Y. (R)
170. Ren Plastics, Inc., 3179 S. Cedar Rd., Lansing 4, Mich. (C)
171. Research Sales, Inc., 20 Fourth Ave., Hawthorne, N.J. (C)
172. Rexton Finishes, Inc., 62 Woolsey St., Irvington 11, N.J. (C)
173. Reynolds Chemical Products Co., Ann Arbor, Mich. (C)
174. Rohm & Haas Co., Resinous Products Div., 222 W. Washington Sq., Philadelphia 5, Pa. (R)
175. Rubber and Asbestos Corp., Bloomfield, N.J. (C)
176. Rubber Corp. of America, Latex and Chemical Div., New South Road, Hicksville, Long Island, N.Y. (R, C)
177. Schenectady Resins Div., Schenectady Varnish Co., Inc., P.O. Box 1046, Schenectady 1, N.Y. (R, C)
178. Schwartz Chemical Co., Inc., 50-01 Second St., Long Island City 1, N.Y. (C)
179. Seal-Peel, Inc., 775 Stephenson Hwy., Royal Oak, Mich. (C)
180. Semet-Solvay Petrochemical Div., Allied Chemical & Dye Corp., 4 Rector St., New York 6, N.Y. (R)
181. Servwell Products Co., 6541 Euclid Ave., Cleveland 3, Ohio (C)
182. Shawinigan Resins Corp., P.O. Box 2130, Springfield 2, Mass. (R)
183. Shell Chemical Corp., Plastics & Resins Div., 50 W. 50th St., New York 20, N.Y. (R)
184. Sherwin-Williams Co., 101 Prospect, Cleveland 1, Ohio (R, C)
185. Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17, N.Y. (R)
186. Soc-co Plastic Coating Co., 13216 Laureldale Ave., Paramount, Calif. (C)
187. Spraylat Corp., 1 Park Ave., New York 16, N.Y. (C)
188. Standard-Toch Chemicals, Inc., Staten Island 3, N.Y. (C)
189. Stanley Chemical Co., The, East Berlin, Conn. (C)
190. Sullivan Chemicals Div., Sullivan Varnish Co., 420 Hart St., Chicago 22, Ill. (C)
191. Synvar Corp., Wilmington 99, Del. (R)
192. Technicraft, 1156 Commonwealth Ave., Boston 34, Mass.
193. Tennessee Eastman Co., Kingsport, Tenn. (R)
194. Thiokol Chemical Corp., 780 N. Clinton Ave., Trenton 7, N.J. (R)
195. Thompson & Co., 1085 Allegheny Ave., Oakmont, Pa. (C)
196. Truscon Laboratories, Inc., Detroit 11, Mich. (C)
197. UBS Chemical Corp., Cambridge 42, Mass. (R, C)
198. Union Carbide Chemicals Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17, N.Y. (R)
199. Union Carbide Plastics Co., 30 E. 42nd St., New York 17, N.Y. (R)
200. U.S. Stoneware Co., Akron 9, Ohio (C)
201. Vacuum Coatings, Wilkinsonville, Mass.
202. Varcum Chemical Corp., Packard Rd., Niagara Falls, N.Y. (R)
203. Velsicol Chemical Corp., 330 E. Grand Ave., Chicago 11, Ill. (R)
204. Warwick Chemical Co., Div. of Sun Chemical Corp., 750 Third Ave., New York, N.Y. (R)
205. Watson-Standard Co., 225 Galveston Ave., Pittsburgh 30, Pa. (C)
206. Western Coating Co., Royal Oak, Mich.; Pasadena 1, Calif. (C)
207. Westinghouse Electric Corp., Micarta Div., Hampton, S.C., and Manor, Pa. (C)
208. Wharry & Co., Inc., G.A., 95 Broad St., New York 4, N.Y. (R)
209. Witco Chemical Co., 122 E. 42nd St., New York 16, N.Y. (R, C)
210. Witte & Sons, John H., Burlington, Iowa (R)
211. Woodmont Products Co., County Line Rd., Huntingdon Valley, Pa.
212. Wyandotte Chemicals Corp., Wyandotte, Mich. (R)
213. Zinsser and Co., Wm., 516 W. 59th St., New York 19, N.Y. (R)

*This chart includes information on sources of film-forming materials for compounding protective coatings, indicated by (R), and sources of protective coatings prepared from the film-forming materials, indicated by (C). Compounding usually involves the addition of water or organic solvents, plasticizers, colorants, defoamers, detackifiers, thickeners, antioxidants, stabilizers, etc.

Films Chart (up to 10 mils thick)*

TYPE OF PLASTIC BASE	ACRYLONITRILE STYRENE COPOLYMER	CELLULOSE ACETATE	CELLULOSE TRIACETATE	CELLULOSE ACETATE BUTYRATE	CELLULOSE NITRATE
1. Method of processing	Two-way stretch orientation	Casting, extrusion	Casting	Casting, extrusion	Block, casting, extrusion
2. Forms available	Rolls	Sheets, rolls, tapes	Sheets, rolls	Sheets, rolls	Sheets, rolls
3. Thickness range, in.	0.001-0.010	0.0005-0.010	0.0008-0.010	0.0011-0.010	0.0005-0.010
4. Maximum width, in.	43	40-60	40-46¼	40 cast 42 extruded	50
5. Area factor[a]	25,400	21,000-22,000	21,200-21,400	23,400	20,000
6. Specific gravity	1.08-1.09	1.28-1.43	1.28-1.31	1.19-1.22	1.42-1.46
7. Tensile strength,[b] p.s.i.	10,000-15,000	5,400-13,900	9,000-16,000	4,100-9,700	10,000-11,000
8. Elongation,[b] percent	20-60	25-45	10-40	40-100	30-40
9. Bursting strength,[c] 1 mil thickness, Mullen points	–	30-70	50-70	50-70	40-50
10. Tearing strength,[d] gm.	–	2-25	4-6	3-5	–
11. Tearing strength,[e] lb./in.	–	55-415	55-395	80-105	–
12. Folding endurance[f]	–	250-400	3,500-4,000[o]	1,200-1,500[o]	50-250
13. Water absorption,[g] 24 hr., percent	–	3.6-6.8	3.5-4.5	0.1-3.4	1.5-2.0
14. Water vapor permeability[h]	0.4-0.5	1.4-8.8 160[x]	4.8-6.0 750[x]	4.5-6.5 730[x]	–
15. Permeability to gases, 10^{-6} g./24 hr./m.^{2}/mm. thick./cm. Hg at 21°C., 0% R.H.	CO_2 210[u] N_2 9[u] O_2 36[u]	CO_2 12000-17500[v] O_2 1700- 2500[v] N_2 160	High	High	–
Resistance rating[i]					
16. Strong acids	G	P	P	P	G
17. Strong alkalies	E	P	P	P	M
18. Grease and oils	G	G	G	F	M
19. Organic solvents	E to P	P[j]	P[j]	P[j]	P[j]
20. Water	E	G	G	G	G
21. High relative humidity	E	G	G	G	G
22. Sunlight	E	G	E	G	P
23. Resistance to heat,[p] °F.	185-220	150-220	300-400	120-180	140
24. Resistance to cold,[p] °F.	–	–	–	–	–
25. Change in linear dimensions at 100°C. for 30 min.,[q] percent	–	+0.2 to –3.0	0 to –0.8	+0.1 to –3.0	–
26. Flammability	Slow burning	Slow to self-extinguishing	Self extinguishing	Slow burning	–
27. Burning rate,[r] in./sec.	–	0.3-2.2	0.2-0.4	1.0-2.4	–
28. Trade designations of films (see list of manufacturers on page 536 for key to numbers in parentheses)	Polyflex 200 (60) Styron 60 (27)	Bexoid (11) Cadco (12) Campco (13) Celanese (15) du Pont (28) Inceloid A (3) Joda C/A (24) Kodapak I (30) Lumarith (15) Medlon (49) Nixon C/A (54) Soplasco (77) Vuepac (52) Wopalon (85)	BX Triacetate (11) Celanese (15) Kodapak IV (30)	Cadco (12) Campco (13) Genco CAB (37) Joda C/AB (24) Kodapak II (30) Medlon (49) Nixon CAB (54) Soplasco (77)	Inceloid N (3) Joda C/N (24) Nixon C/N (54) Wopaloid (85) Xylonite (11)
29. Manufacturers or processors of films (numbers refer to list on page 536)	7, 27, 60	3, 11, 12, 13, 14, 15, 24, 28, 30, 37, 49, 52, 54, 73, 75, 77, 83, 85	7, 11, 15, 30, 77	7, 12, 13, 24, 30, 37, 49, 54, 75, 77	3, 7, 11, 24, 28, 54, 77, 85

*Footnotes are on p. 536

ETHYL CELLULOSE	METHYL CELLULOSE	POLYAMIDE (NYLON)	POLYTRIFLUOROCHLOROETHYLENE	POLYMETHYL METHACRYLATE	POLYETHYLENE		
					LOW DENSITY	MEDIUM DENSITY	HIGH DENSITY
1. Casting	Casting	Extrusion	Casting, extrusion, molding	Extrusion, two-way stretch, orientation	Calendering, extrusion	Calendering, extrusion	Calendering, extrusion
2. Sheets, rolls, tapes	Rolls and sheet	Rolls	Tubing, rolls, sheets, tapes	Rolls, sheets	Rolls, sheets, tapes, tubes	Rolls, sheets, tapes, tubes	Rolls, sheets, tapes, tubes
3. 0.003-0.020	0.001-0.003	0.0005-0.010	0.002-0.010	0.005-0.010	0.0004-0.010	0.0004 or more	0.0004-0.010
4. 28-40	32	60	20	43	480	480	60
5. 24,000	22,500	24,000	12,000	23,400	30,000	29,500	29,000
6. 1.14-1.16	1.23	1.08-1.14	2.1-2.2	1.18-1.19	0.910-0.929	0.926-0.940	0.941-0.965
7. 6,800-10,600	5,400	9,000	6,300-6,600	8,200-8,800	1,350-2,500	2,000-3,500	2,400-6,100
8. 25-40	58	Orients	90-300	4-12	200-800	5-500	10-650
9. 50-85	18	–	42 (2 mil film)	–	–	–	–
10. 7-36	–	–	200-350	–	60-200	50-300	15-300
11. 215-395	–	1,300	–	340-380	65-575	–	–
12. >2,700	Good	–	–	–	Very high	Very high	Very high
13. 2.5-7.5	High	1.0-1.5	0.00	0.3-0.4	0-0/8	nil	nil
14. 4.8-14.2 ∣ ~50^v	70.2^v	0.3-1.8	0.00	0.5	0.04-0.08	0.03-0.06	0.02-0.04
15. O_2 3500^w CO_2 7800^w N_2 1100^w	N_2 29^w CO_2 400^w O_2 80^w	CO_2 160 O_2 25 (50% R.H.)	–	–	CO_2 12,000 O_2 1,900 N_2 400	9,000 1,500 –	6,200-3,300 800-450 100-50
16. F to P	P	P	E	G	E	E	E
17. E	G	E	E	G	E	E	E
18. G	E	E	E	P	M to G	G	G
19. P	G to P	E	E	–	G°(60°C)	G	G (80°C)
20. E	Soluble	E to P	E	G	E	E	E
21. E	G to P	E to P	E	G	E	E	E
22. G to F	Fair	–	E	E	F	G	F
23. 200-250	Dry, 430	180-380	300	155-190	200	220	250
24. −90	Excellent	−60	−80	Good	−50	−60	−70
25. 0 to −0.7	–	–	–	–	+10.4 to −19.9	+10.4 to −19.9	nil
26. Slow burning	Slow Burning	Self-extinguishing	Nonflammable	Slow burning	Slow burning	Slow burning	Slow burning
27. 0.3-0.6	–	–	–	0.1	–	–	–
28. Campco (13) Ethocel (27) Inceloid E (3) Joda E/C (24) Nixon E/C (54) Soplasco (77)	Methocel (27)	Cadco (12) Chemiseal (80) Clopay (18) Fairlon (17) Fosta-Nylon(35) Nylam (43) Plastex (57) Polypenco N (63, 64) Soplasco (77) Supronyl (63)	Fluorothene (generic) (8) Triplex (60) Trithene (82)	Methaflex (60)	Arnar (71, 72) Bexthene (11) BiSeal (9) CRC (14) Cadco (12) Campco (13) Cheslene TF (16) Clopay (18) Conolex (20) Durethene (29) Extrudo-Film (33) Fairlon (17) Firestone (34) Ger-Pak (39) H & R (43) Jodapac (24) Katharon (71, 72) Layflat (60) Midlon (49) Natvar (53) Nixon (54) Olin PE (55) Plastic Horizons (59) Plicose (61) Polyfilm (32) Polyken (47) Polytex (56) Polython (62) Polytreat (32) Prestolene (65) Reet (71, 72) Relthene (67) Resinol (1) Reynolon (70) Shellene (20) Soplasco (77) Spunglow (71, 72) Thermolene (20) Visqueen (82)		
29. 3, 7, 13, 24, 27, 49, 54, 77	7, 27	7, 12, 17, 18, 20, 35, 43, 57, 59, 63, 64, 77, 80	7, 36, 60, 77, 82, 84	7, 60, 73, 77, 83	1, 5, 7, 8, 11, 12, 13, 14, 16, 17, 20, 22, 24, 25, 28, 29, 32, 33, 34, 39, 43, 47, 49, 53, 55, 56, 59, 60, 61, 62, 65, 67, 70, 71, 72, 73, 75, 77, 81, 82, 83, 84		

TYPE OF PLASTIC BASE	POLYPROPYLENE	POLYETHYLENE TEREPHTHALATE	POLYTETRA-FLUORO-ETHYLENE	POLYSTYRENE		POLYVINYL ALCOHOL
1. Method of processing	Extrusion	Casting, extrusion	Skiving, casting, extrusion	Casting, extrusion	Oriented	Casting
2. Forms available	Sheets, rolls, tapes	Sheets, rolls, tapes	Sheets, tapes, tubing	Rolls, sheets	Rolls, sheets	Rolls, sheets, tapes
3. Thickness range, in.	0.0005 and up	0.00025-0.0075	Up to 0.010	0.0004 and up	0.001-0.010	0.0005-0.012
4. Maximum width, in.	60	50-55	38	40-54	43	54
5. Area factor[a]	30,667	20,000	12,800	26,100	26,100	21,600
6. Specific gravity	0.9	1.38-1.39	2.1-2.2	1.05-1.06	1.05-1.06	1.21-1.31
7. Tensile strength,[b] p.s.i.	5,000-10,000	17,000-23,700	1,500-4,000	7,100-12,100	7,100-12,100	4,000-10,000
8. Elongation,[b] percent	over 200	35-110	100-350	3-40	3-10	180-600
9. Bursting strength,[c] 1 mil thickness, Mullen points	–	45-60	–	35-45	–	–
10. Tearing strength,[d] gm.	32-1,750	10-27	10-100	25	–	250-800
11. Tearing strength,[e] lb./in.	–	650-1,740	–	270-495	270-495	785-890
12. Folding endurance[f]	Very high	20,000	–	–	–	–
13. Water absorption,[g] 24 hr., percent	0.005 or less	<0.5	0.00	–	0.04-0.06	80
14. Water vapor permeability[h]	0.06	0.05-0.15(MP)	0.0	0.5-0.7 | 6.0[v]	0.5-0.7	0.1
15. Permeability to gases, 10^{-6} g./24 hr./m.^{2}/mm. thick./cm. Hg at 21°C., 0% R.H.	–	CC_2 <0.5 O_2 <0.5 N_2 <0.5	–	–	Air 105[u] CO_2 1080[u] H_2 2420[u] N_2 49.5[u] O_2 310[u]	CO_2 200 O_2 120 (50% R.H.)
Resistance rating[1]						
16. Strong acids	E	G	E	G	G	P
17. Strong alkalies	E	G	E	E	E	P
18. Grease and oils	G	E	E	G	G	E
19. Organic solvents	G	E	E	E to P	E to P	E
20. Water	E	E	E	E	E	P
21. High relative humidity	E	E	E	E	E	P
22. Sunlight	F to E	M	E	G to F	G	E
23. Resistance to heat,[p] °F.	190-220	300	500	175-200	175-220	G
24. Resistance to cold,[p] °F.	-60	-80	<-130	-55	–	–
25. Change in linear dimensions at 100°C. for 30 min.,[q] %	–	<0.5	–	-4.6 to -37.4	–	-3.2
26. Flammability	Slow burning	Slow burning to self-extinguishing	Nonflammable	Slow burning	Slow burning	Slow burning
27. Burning rate,[r] in./sec.	–	–	–	–	–	0.8-0.9
28. Trade designations of films (see list of manufacturers on page 536 for key to numbers in parentheses)	Proplene (48)	Melinex (46) Mylar (28)	Polypenco T (63,64) Scotch (50) Teflon (28)	Cadco (12) Campco (13) Dielect A-9 (26) Joda P/S (54) Soplasco (77)	Polyflex 100 (60) Styroflex (53) Styrofoil (11) Trycite (27)	Inceloid (3) Mono-Sol (51) Reynolon (70)
29. Manufacturers or processors of films (numbers refer to list on page 536)	7, 48, 50, 53, 70, 76	7, 28, 46	7, 21, 23, 50, 63, 64, 77, 80	7, 12, 13, 24, 26, 27, 37, 49, 54, 73, 75, 77, 83, 84	7, 11, 49, 53, 60, 77	3, 7, 51, 70, 77

*Footnotes are on p. 536

	POLYVINYL CHLORIDE		VINYL CHLORIDE-ACETATE COPOLYMERS		VINYLIDENE CHLORIDE-VINYL CHLORIDE COPOLYMER	REGENERATED CELLULOSE (CELLOPHANE)	RUBBER HYDRO-CHLORIDE	VINYL-NITRILE RUBBER
	Rigid	*Nonrigid*	*Rigid*	*Nonrigid*				
1.	Calendering, casting, extrusion	Calendering, casting, extrusion	Calendering, extrusion, casting		Calendering, casting, extrusion	Extrusion into bath	Casting	Casting, extrusion
2.	Sheets, rolls, tapes	Sheets, rolls, tapes	Sheets, rolls (nonrigid also in tapes, tubes)		Rolls	Sheets, rolls, ribbons	Rolls, sheets, tapes	Rolls, sheets, tapes, tubing
3.	0.001-0.010	0.001-0.010	0.001-0.010	0.001-0.010	0.0005-0.010	0.0009-0.0017	0.0004-0.0025	0.001-0.003
4.	54-84	54-84	54	84	40-54	60	60	11.5-41.5
5.	20,000-23,000	20,000-23,000	21,000	21,000	16,000-23,000	11,500-21,000	25,000	22,800-23,700
6.	1.35-1.45	1.24-1.45	1.30-1.39	1.20-1.35	1.20-1.68	1.40-1.50	1.11	1.18-1.21
7.	7,000-10,000	1,400-5,600	5,500-8,000	2,000-4,500	8,000-20,000	7,000-15,000	3,500-5,000	2,500-4,000
8.	25	150-500	2-10	150-500	20-140	10-50	200-800	250-500
9.	30-40	20	–	20	25-35	55-65	Stretches	–
10.	10-700	60-1,400	10-30	30-1,400	10->100	2-10	60-1,600	200-960
11.	110-490	110-490	–	–	80-465	110-515	–	–
12.	–	–	–	–	>500,000	–	250,000	Very high
13.	Negligible	Negligible	Negligible		Negligible	45-115	5	Negligible
14.	0.35-2.0	0.35-2.0	–	0.23	0.01-0.03	1.4-2.7(NMP) 0.008-0.03(MP)	0.007-0.23^a	–
15.	CO_2 970 O_2 150 (50% R.H.)	CO_2 970 O_2 150 (50% R.H.)	–	–	CO_2 12 O_2 2.4 (50% R.H.) O_2 0.9-5.9^w CO_2 3.8-42.3^w N_2 0.13-1.6^w Air 0.21-2.6^w	CO_2 3 O_2 <0.5 N <0.5	CO_2 288-13,500^t O_2 38-3,250^t	Low
16.	E	E	E	E	E	P	G	G
17.	E	E	E	E	E to G	P	G	G
18.	G	G	E	M to E	E to G	E	E	E
19.	G	G	P to E	P to E	E to G	Moistureproof coating attacked	G^n	G^m
20.	E	E	E	E	E	M	E	E
21.	E	E	E	E	E	M	E	E
22.	G	G	G	G	G	G	F	M
23.	150-200	150-200	Fair	150-200	150-200(dry); 300(wet)	300	180-205	200
24.	–50	–50	Good	Good	–25 to –50	Good	–20	32
25.	+4.2 to –9.5	+4.2 to –9.5	–	–	–	–0.7 to –3.0	–	–
26.	Slow to self-extinguishing	Slow to self-extinguishing	Slow burning to self-extinguishing		Self-extinguishing	Slow burning	Self-extinguishing	Slow burning
27.	0.2-1.7	0.2-1.7	–	–	–	0.7-2.3	–	–
28.	*Rigid* Arnar (71,72) Bakelite (79) Clopay (18) Cobex(11) Col-O-Vin (19) Joda PVC (24) Nixon Vine-L (54) Pantex (56) Reet (71, 72) Resproid (69) Rucoam (74) Seilon (76) Soplasco (77) Tolon (78) Velon (34) Wopavin (85)	*Nonrigid* Arnar (71, 72) Bakelite (79) Bishop (elect. cond) (8) Boltaflex (9) Breeth-ees (66) Clopane (18) Col-O-Vin (19) Coveray (18) Dorn (42) Fabray (18) Fabtex (18) Fashion (38) Ger-Pak (39) Hyben (6) Koroseal (40) Mono-Sol (51) Naugahyde (81) Pantex (56) Prestoflex (65) Randfilm (66) Randflex (66) Reet (71, 72) Resiloid (31) Resinite (10) Resproid (69) Reynolon (70) Rucoam (74) Soplasco (77) Spunglow (71,72) Syntilon (58) Tolon (78) Ultron (52) Valbex (11) Velon (34) Vinylfilm (41) Visten (82) Vitafilm (41) Vitalon (41) Vylene (31) Wataseal (44) Wopavin (85)	Arnar (71, 72) Bakelite (79) Col-O-Vin (19) Joda PVC (24) Nixon Vin-L (54) Pantex (56) Reet (71, 72) Resproid (69) Rucoam (74) Seilon (76) Soplasco (77) Tolon (78) Velon (34) Vinylite (14) Wopavin (85)	Arnar (71, 72) Bakelite (79) Col-O-Vin (19) Condulon (58) Dorn (42) Fabray (18) Fabtex (18) Krene (79) Nixon Vine-L(54) Pantex (56) Randfilm (66) Reet (71, 72) Resproid (69) Revelry (78) Reynolon (70) Rucoam (74) Soplasco (77) Syntilon (58) Tolon (78) Vinylite (79) Vinylite (14) Wataseal (44) Wopavin (85)	Arnar (71, 72) Pantex (56) Randfilm (66) Reet (71, 72) Saran (27) Saran Wrap (27)	Avisco cellophane (4) du Pont cellophane (28) Olin cellophane (55)	Pliofilm (41)	Arnar (71, 72) Randfilm (66) Reet (71, 72) Visten (82)
29.	7, 11, 14, 19, 24 34, 42, 56, 69, 71, 72, 73, 74, 76, 77, 78, 79, 83, 85	2, 6, 7, 8, 10, 11, 14, 18, 19, 28, 29, 31, 34, 38, 39, 40, 41, 42, 44, 51, 52, 54, 56, 58, 65, 66, 69, 70, 71, 72, 74, 75, 77, 78, 79, 82, 85	7, 14, 19, 24, 34, 42, 56, 69, 71, 72, 73, 74, 76, 77, 78, 79, 83, 85	7, 14, 18, 19, 42, 44, 54, 56, 58, 66, 69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 81, 83, 85	7, 27, 56, 66, 74, 82	4, 7, 28, 55	7, 41, 77	42, 66, 70, 71, 72, 77, 82

LIST OF MANUFACTURERS AND PROCESSORS OF FILMS*

1. Allied Resinous Products, Inc., 525 W. Adams St., Conneaut, Ohio
2. American Lucoflex, Inc., 500 Fifth Ave., New York 36, N.Y.
3. American Products Mfg. Co., 8127 Oleander St., New Orleans 18, La. (0.5 to 3 mils)
4. American Viscose Corp., Film Div., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.
5. Amos Packaging, Div. of Amos-Thompson Corp., Edinburg, Ind.
6. Associated Rubber and Plastic Corp., 2780 Park Ave., New York 51, N.Y.
7. Auburn Plastics Inc., 511 Fifth Ave., New York 17, N.Y.
8. Bishop Manufacturing Corp., 10 Canfield Rd., Cedar Grove, N.J.
9. Bolta Products, Div. of The General Tire & Rubber Co., Lawrence, Mass.
10. Borden Chemical Co., The, Div. of The Borden Co., Resinite Dept., Santa Barbara, Calif., and North Andover, Mass.
11. BX Plastics Ltd., Hingham Station Ave., Chingford, London E.4, England
12. Cadillac Plastic and Chemical Co., 15111 Second Ave., Detroit 3, Mich.
13. Campco Div., Chicago Molded Products Corp., 1020 N. Kolmar Ave., Chicago 51, Ill.
14. Canadian Resins & Chemicals Ltd., 600 Dorchester St. W., Montreal 2, Que., Canada
15. Celanese Corp. of America, 744 Broad St., Newark 5, N.J.
16. Chester Packaging Products Corp., 684 Nepperhan Ave., Yonkers, N.Y.
17. Chippewa Plastics, Inc., Chippewa Falls, Wis.
18. Clopay Corp., Film Products Div., Clopay Sq., Cincinnati 14, Ohio
19. Columbus Coated Fabrics Corp., 7th & Grant Aves., Columbus 16, Ohio
20. Continental Can Co., Inc., Flexible Packaging Div., Mt. Vernon, Ohio
21. Continental-Diamond Fibre Co., Newark, Del.
22. Contour Extrusion Co., 517 Fayette Ave., Mamaroneck, N.Y.
23. Crane Packing Co., 6400 Oakton St., Morton Grove, Ill.
24. Davis Plastics Co., Joseph, Schuler & Quincy Aves., Arlington, N.J.
25. Deerfield Plastics Co., Inc., 271 Main St., South Deerfield, Mass.
26. Dielect Inc., Fords, N.J.
27. Dow Chemical Co., The, Midland, Mich.
28. du Pont de Nemours & Co. (Inc.), E. I., Film Dept., Wilmington 99, Del.
29. Durethene-Koppers Co., Inc., 7001 W. 60th St., Chicago 38, Ill.; 5600 W. Arbor Vitae St., Los Angeles, Calif.
30. Eastman Kodak Co., Rochester 4, N.Y.
31. Elm Coated Fabrics Co., 261 Fifth Ave., New York 16, N.Y.
32. Extruders, Inc., 3232 W. El Segundo Blvd., Hawthorne Calif.
33. Extrudo-Film Corp., 36-35 36th St., Long Island City 6, N.Y.
34. Firestone Plastics Co., Pottstown, Pa.
35. Foster Grant Co., Inc., Leominster, Mass.
36. Garlock Packing Co., Palmyra, N.Y.
37. General Plastics Corp., 1400 N. Washington St., Marion, Ind.
38. General Tire & Rubber Co., Pennsylvania Div., Jeannette, Pa.
39. Gering Products Inc., N. 7th St. & Monroe Ave., Kenilworth, N.J.
40. Goodrich Co., The B.F., Akron 18, Ohio
41. Goodyear Tire & Rubber Co., Akron 16, Ohio
42. Gordon-Lacey Chemical Products Co., Inc., Maspeth, L.I., N.Y.
43. H & R Industries, 344 E. Walnut St., Nazareth, Pa.
44. Harte & Co., Inc., 16 E. 34th St., New York 16, N.Y.
45. Hyben Plastic Fabrics, Inc., 201 E. 146th St., New York 51, N.Y.
46. Imperial Chemical Industries Ltd., Milbank, London S.W. 1, England
47. Kendall Co., 309 W. Jackson Blvd., Chicago 6, Ill.
48. Ludlow Papers, Inc., Needham, Mass.
49. Midwest Plastic Products Co., 1801 Chicago Rd., Chicago Heights, Ill.
50. Minnesota Mining & Mfg. Co., 900 Fauquier Ave., St. Paul 6, Minn.
51. Mono-Sol Corp., 407 County Line Rd., Gary, Ind.
52. Monsanto Chemical Co., Plastics Div., Springfield 2, Mass.
53. Natvar Corp., 211 Randolph Ave., Woodbridge, N.J.
54. Nixon Nitration Works, Nixon, N.J.
55. Olin Mathieson Chemical Corp., Film Div., 655 Madison Ave., New York 21, N.Y.
56. Pantasote Co., 26 Jefferson St , Passaic, N.J.
57. Plastex Process Co., 230 W. Passaic St., Maywood, N.J.
58. Plastic Film Co., Inc., Plainfield, Conn.
59. Plastic Horizons Inc., 1 Erie St., Paterson, N.J.
60. Plax Corp., P.O. Box 1019, Hartford, Conn.
61. Plicose Mfg. Corp., 71-77 Box St., Brooklyn 22, N.Y.
62. Poly-Plastic Products, Inc., 2 Fourth Ave., Paterson 4, N.J.
63. Polymer Corp. of Pennsylvania, 2140 Fairmont Ave., Reading, Pa.
64. Polypenco, Inc., 2150 Fairmont Ave., Reading, Pa.
65. Presto Plastics Products Co., Inc., 11 E. 26th St., New York 10, N.Y.
66. Rand Rubber Co., Summer Ave. & Halsey St., Brooklyn 16, N.Y.
67. Reliance Plastic & Chemical Corp., 110 Kearney St., Paterson 2, N.J.
68. Resinite Dept., The Borden Chemical Co. (see No. 10 above)
69. Respro, Div. of The General Tire & Rubber Co., 530 Wellington Ave., Cranston 10, R.I.
70. Reynolds Metals Co., Plastics Div., P.O. Box 128, Grottoes, Va.
71. Ross & Roberts, Inc., 1299 W. Broad St., Stratford, Conn.
72. Ross & Roberts Sales Co., Inc., 350 Fifth Ave., New York 1, N.Y.
73. Rotuba Extruders, Inc., 437 88th St., Brooklyn 9, N.Y.
74. Rubber Corp. of America, New South Rd., Hicksville, L.I., N.Y.
75. Scranton Plastic Laminating Corp, 3218 Pittston Ave., Scranton, Pa.
76. Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio
77. Southern Plastics Co., 408 Pendleton St., Columbia, S.C.
78. Textileather Div., The General Tire & Rubber Co., 607 Madison Ave., Toledo 3, Ohio
79. Union Carbide Plastics Co., 30 E. 42nd St., New York 17, N.Y.
80. United States Gasket Co., Plastics Div. of The Garlock Packing Co., 602 N. 10th St., Camden 1, N.J.
81. United States Rubber Co., 1230 Ave. of the Americas, New York 20, N.Y.
82. Visking Corp., Plastic Div., Terre Haute, Ind.
83. Waljohn Plastics, 437 88th St., Brooklyn 9, N.Y.
84. Westlake Plastics Co., Lenni Mills, Pa.
85. Worbla Ltd., Papiermuhle-Berne, Switzerland

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*The values reported in this chart are only for films up to 0.01 in. in thickness. The information was obtained from various sources. Special grades of these materials may be obtained which excel in some particular property. Manufacturers should be consulted for additional or specific information or for new uses of their materials.

[a] Square in. per lb. of film in 1 mil (0.001 in.) thickness. Figures may vary with resin plasticizer ratio. [b] ASTM D882, procedure B. [c] ASTM D774. [d] Elmendorf test. Figures represent pull required to continue tear of 1 mil thick film after starting. Force required to start tear is too high to measure on same equipment and therefore is not normally determined. [e] SPI-ASTM D1004, static-weighing method. [f] Using 1 mil thick film and the Schopper Bending Endurance Tester, unless otherwise noted. [g] ASTM D570. [h] ASTM D697; values are in grams/24 hr./m.^{2}/mm. thickness/cm. Hg at 25°C. [i] Code for rating: E = Excellent, G = Good, M = Moderate, F = Fair, P = Poor. [j] Except aliphatic and petroleum hydrocarbons. [k] Except H_2SO_4 and HNO_3. [l] Except NH_4OH. [m] Except ketones and esters. [n] Except chlorinated solvents, ketones, esters, and hot aromatic hydrocarbons. [o] Except hydrocarbons and chlorinated solvents. [p] These compositions are the thermoplastic materials that gradually become softer as the temperature increases. The maximum and minimum service temperature will depend on formula of material, design of part and service conditions such as amount of stressing, humidity, etc. Requirements for resistance to heat and cold should be considered as special problems. Where a range of values is given in the chart, the low value is the limiting temperature for continuous exposure and the high value for intermittent exposure. [q] ASTM D1204. [r] Paragraph 4.10 in Commercial Standard CS192-53. [s] Grams/24 hr./100 sq. in. at 100°F. and 90% relative humidity. [t] cc./24 hr./100 sq. in. at 25°C. and 0% relative humidity. [u] cc./24 hr./100 sq. in./mil thickness/cm. Hg at 25°C. [v] Water vapor perm. in gm./100 sq. in.-mil thickness—24 hr.—atmosphere. [w] Perm. to gases in cc./100 sq. in.-mil thickness—24 hr.—atmosphere. [x] ASTM D570-42 in gm./sq. in./24 hr. on 0.001 butyrate, 0.001 triacetate, and 0.010 acetate. [y] Determined on 1 mil film.

PROPERTY	THE GLIDDEN COMPANY, 900 Union Commerce Bldg., Cleveland 14, Ohio									
Resin Number	Glidpol 1001, 1012. General-purpose; variably reactive; rigid.	Glidpol 1017. High heat distortion; rigid.	Glidpol 1018. Fire retardant; rigid.	Glidpol 1019. semi-rigid;	Glidpol 1021. Acrylic modified; light stabilized.	Glidpol 1022. 1022 TX. Fast R.T. cure.	Glidpol 1032 Fast R.T. Cure Thixotropic	Glidpol 2002. Flexible	Glidpol 3100 series. Gel-Kote resins.	Glidpol 4000 series. Coating resins 100% reactive.
Identity	Unsaturated polyester resin									
Viscosity at 25° C., cp.	600–1000	1500	1700	800–2200	200	600	500	100	Thixotropic	50–2000
Storage life of resin	4 to 6 months at 77° F.									
Resin content as applied, %	100% reactive									
Storage life of treated material	2 hours to 5 days, depending on catalyst used.					10-90 minutes	10-90 minutes	2 hrs.-5 days	10-60 minutes	2 hrs.-5 days
Curing cycle Pressure, p.s.i.	Contact pressure and up.									Capable of air dry in 4 hr. Cured at elevated temperatures (200-300° F.) in 2 to 15 min.
Temperature, °F.	Room temperature to 300° F. depending on resin and catalysts.									
Time, min.	1-120 depending on temperature, catalysts, and resin mass.									

PROPERTY	GENERAL ELECTRIC COMPANY, 1211 N. Olive St., Anaheim, Calif. (see also p. 546)							EMERSON AND CUMING, INC. Canton, Mass.
Resin number	AR401	AR403	AR455	AR458	AR463	AR493	AR1075 High-temp.	Eccomold L 65. Low elec. loss
Identity	Unsaturated polyester resin							Cross-linked styrene
Viscosity at 25° C., cp.	3000–4000	2000–3000	200–335	200–335	Thixotropic	2000–3000	5000–7000	1000 cps.
Storage life of resin	No catalyst, refrigerated: indefinitely No catalyst, room temperature: 4 mo. (min.)							No catalyst, Indefinitely.
Resin content as applied, %	30 to 80							
Storage life of treated material	With 1% benzoyl peroxide 4 days at room temperature							At least 1 wk.
Curing cycle Pressure, p.s.i.	Contact to 300 (or beyond if desired)							Contact and up
Temperature, °F.	Matched-die molding and laminating: 230-260. Also room temperature cure with accelerators.							150–250
Time, min.	Heat cure: 1-30 depending upon temperature and conditions. Room temperature cure: 5 min. to several hours depending upon conditions							150 °F.: 4 hr. 250 °F.: 1 hr.

PROPERTY	SHERWIN-WILLIAMS CO., INDUSTRIAL DIV., 101 Prospect Ave., Cleveland 1, Ohio							
Resin number	Dypol V59 V A1	Dypol V59 V A3	Dypol V59 V A4	Dypol V59 V A5	Dypol V59 V A6	Dypol V59 V A7	Dypol V59 V 10	Dypol V59 V 11
Identity	Rigid, light stable polyester	Acrylic, light stable polyester	Thixotropic polyester	Premix polyester	Acrylic, light stable polyester	Applicator polyester resin	Rigid, general-purpose medium viscosity polyester resin	Rigid, general-purpose heavy viscosity polyester resin
Monomer	Styrene	Methyl methacrylate styrene	Styrene	Vinyl toluene	Methyl methacrylate	Styrene	Styrene	Styrene
Viscosity at 25° C., cp.	250–375	200–300	400–500	2500–4000	2700–3600	400–500	500–885	1760–2270
Storage life of resin	3 to 6 months at 77° F.							
Curing cycle Pressure, p.s.i.	Contact and up							
Temperature °F	Room temperature cure: 5 min. to several hours, depending on catalyst conditions.							
Time, min.	Heat cure: 30 sec. and up, depending on catalyst and conditions.							

PROPERTY	INTERCHEMICAL CORPORATION FINISHES DIVISION, 1754 Dana Avenue, Cincinnati 7, Ohio							
Resin number	IC-312	IC-420-2	IC-382	IC-401	IC-766	IC-625	IC-636	IC-638
Identity	Standard general-purpose	HV rigid, light stable	HHDT rigid	Flexible	Rigid, fast cure	Rigid, chemical-resistant	FR Polyester	Rigid, non-volatile
Viscosity at 25° C., cp.	2100-2700	45,000-75,000	2100-2700	300	600-700	2100-2700	2100-2700	45,000
Storage life of resin	60° F.: 9-12 mo.; 75° F.: 4-6 mo.; 85° F.: 2-3 mo.							
Monomer, %	Styrene 30	Styrene 22	Styrene 30	Styrene 30	Styrene 35	Styrene 30	Styrene 25	DAP
Storage life of treated material	Catalized with 1% benzoyl peroxide: Room temperature: 3-5 days; at 100° F. > 24 hr.							
Curing cycle Pressure, p.s.i.	0 to 500							
Temperature, °F.	Room temperature to 250, depending on the catalyst system and amount of resin							
Time, min.	1 to 30, depending on temperature, catalyst system, and amount of resin.							

PROPERTY	INTERCHEMICAL CORPORATION FINISHES DIVISION, 1754 Dana Avenue, Cincinnati 7, Ohio					CIBA COMPANY, INC., Plastics Division, Kimberton, Pa.	
Resin number	IC-671	IC-947	IC-1400	IC-970	IC-990	Araldite 6005, 6010, 6020, 6071, 6075	Araldite 502, 506, 6005, 6010, 6020
Identity	Rigid, fast cure	Resilient, non-volatile	Resilient polyester, fast cure	Wax resin	Resilient, high tensile, good hot strength	Epoxy resins Dry lay-up	Epoxy resins Wet lay-up
Viscosity at 25° C., cp.	8,000-11,000	60,000	900-1100	Solid	2400	Can be adjusted to suit	900-25,000
Storage life of resin	60° F.: 9-12 mo.; 75° F.: 4-6 mo.; 85° F.: 2-3 mo.					At least one year	At least one year
Monomer, %	Vinyltoluene 30	DAP	Vinyl-toluene 30	None	Styrene 30	Resin content 30-35%	30-35
Storage life of treated material	Catalyzed with 1% benzoyl peroxide: Room temperature: 3-5 days; at 100° F., > 24 hr.					Dicyandiamide: unlimited at room temp. Methylenedianiline: 2-3 wk. at room temp.; 6 mo. at 40° F. Diaminodiphenyl sulfone: 3 mo. at room temp.	Depends on hardener used
Curing cycle Pressure, p.s.i.	0 to 500					Contact and up	Contact and up
Temperature, ° F.	Room temperature to 250, depending on the catalyst system and amount of resin					Dicyandiamide: 345 Methylenedianiline: 300 Diaminodiphenyl sulfone: 300	60-350
Time, min.	1 to 30, depending on temperature, catalyst system, and amount of resin.					Dicyandiamide: 30 Methylenedianiline: 5-30 Diaminodiphenyl sulfone: 60 (with accelerator)	10-60 up to 2 days for 60-80° F. curing

PROPERTY	SCOTT BADER & CO., LTD., Wollaston, Wellingborough, Northamptonshire, England								
Resin number	Crystic 182 Flexible plasticizing resin	Crystic 189 LV, 189 MV, 189 HV water and chemical resistant	Crystic 191 LV, 191 MV, 191 HV Translucent sheeting	Crystic 195 Transparent sheeting	Crystic 196 Contact molding	Crystic 198 Heat resistant	Crystic 212 Hot matched-metal molding	Crystic 300 Self extinguishing	Crystic Pregel 17 Modifying resin
Identity	Unsaturated polyester resins								
Viscosity at 25° C., cp.	800-1000	189 LV 335-385 189 MV 800-1000 189 HV 3500-4500	191 LV 325-375 191 MV 800-1000 191 HV 3500-4500	140-190	800-1000	500-700	2700-3300	1000-1200	Thixotropic
Storage life of resin	6-12 mo. at 68° F. in the dark								
Resin content as applied, %	100% reactive								
Storage life of treated material	8 hr. to several days, depending on catalyst, type of resin, and storage temperature								
Curing cycle Pressure, p.s.i.	Contact to 100 or higher								
Temperature, °F.	Room temperature to 270, depending on catalyst or catalyst-accelerator system								
Time, min.	1 to 10 for hot curing; 15 to several hr. for cold curing, depending on catalyst-accelerator formulation and content								

PROPERTY	PITTSBURGH PLATE GLASS CO., Research and Development Center, Springdale, Pa.								
Resin number	Selectron 5000 series. Rigid general use		Selectron 5155 Light stabilized	Selectron 5119 Room temp. curing	Selectron 5834, 5809, 5807A Room temp. curing	Selectron 5835 Two-pot sprayable, room temp. curing	Selectron 5140 Premix	Selectron 5158 Preform molding	Selectron 5200 series. flexible
Identity	Unsaturated polyester resins								
Viscosity at 25° C., cp.	50-100,000 Adjustable		2,500	625	Thixotropic	Thixotropic	2500	2500	50-2,000
Storage life of resin	40° F.: over 1 yr. No catalyst in dark: 77° F.: over 4 mo. 150° F.: 5 or more days depending on resins								
Resin content as applied, %	35-80		72	65	60-75	60-75	12-35	55-70	50-70
Storage life of treated material	Room temp. 12 hr. - 21 days with benzoyl peroxide depending on resin		48 hrs. @ 77°F. with benzoyl peroxide	2 days @ 77°F. with benzoyl peroxide; 0.1 - 5 hr. with ketone peroxides	0.1 - 5 hr. with methyl ethyl ketone peroxide	7 days with benzoyl peroxide, 7 days with DMA	20 hr. at 100° F.	2 days at 100° F.	12 hr. - 7 days with benzoyl peroxide
Curing cycle									
Pressure, p.s.i.	Preform 0-300	Premix 50-2000	Contact to 300				50-2000	Contact to 300	
Temperature, °F.	140-250	325 Max.	140-250 depending on catalyst	Room temp. to 180	Room temp. to 180	Room temp. to 180	230-320	180-280	180-250
Time, min.	1 - 5	1/2-3	1 - 5	10 min. to 48 hr. depending on catalyst	10 min. to 24 hr. depending on catalyst	10 min. to 8 hr. depending on catalyst	0.5 - 2.0	0.5 - 15	15 - 60

PROPERTY	ROHM AND HAAS CO., Washington Square, Philadelphia 5, Pa.								
Resin number	Paraplex P-13. Flexible	Paraplex P-43, P-49. Rigid	Paraplex P-43HV. Rigid	Paraplex P-47. Semi-rigid	Paraplex P-433. Light stabilized	Paraplex P-444A. Light stabilized	Paraplex P-446A. Light stabilized	Paraplex P-462. Air-curing	Paraplex P-463. Air-curing Thixotropic
Identity	Polyester — styrene resin					Polyester/ MMA	Polyester/ MMA/ styrene	Polyester/ styrene resin	Polyester/ styrene resin
Viscosity at 25° C., cp.	340-480	2100-4500	58000-77000	1400-2600	6600-8700	2800-3500	5000-6500	550-750	600
Storage life of resin	Absence of light, room temperature, no catalyst — 6 mos. (Refrigeration increases stability.)								
Resin content as supplied, %	50	70-73	80	72-76	74	75	75	67	60
Storage life of treated material	1 - 6 days at room temperature when catalyzed with 1% benzoyl peroxide							10 minutes or longer, depending on concentration and type of catalyst used	
Curing cycle									
Pressure, p.s.i.	Contact to 300								
Temperature, °F.	Room temperature to 300° F., depending on type, amount of catalyst and accelerators used as well as on processing conditions								
Time, min.	From 1 min. to several hours depending on type of process								

PROPERTY	BRITISH RESIN PRODUCTS LIMITED Devonshire House, Piccadilly, London, W.1., England									
Resin number	Cellobond A 261/4 General Purpose resin	Cellobond A 273/14 Gel coat resin	Cellobond A 2623 Hot setting resin	Cellobond A 2652 Wet lay-up resin	Cellobond A 2710 Roofing resin	Cellobond A 2531 Roofing resin	Cellobond A 250 Chemical resisting resin	Cellobond A 2660 Heat stable	Cellobond A 2591 Plasticizing resin	Cellobond A 2601 Preform Binder
Identity	Polyester/styrene									
Viscosity at 25° C., cp.	Thixotropic	Thixotropic	450-900	Thixotropic	125-210	80-125	1900-2600	800-1200	300-600	—
Storage life of resin	6-9 mo. at 77° F., sealed, in the dark									3 mo. at 77°F., sealed, in the dark
Resin content as applied, %	75	75	65	65	—	55	70	65	70	50
Storage life of treated material	About 5 days with 1% benzoyl peroxide About 2 days with 1% MEK peroxide or HCH									
Curing cycle										
Pressure, p.s.i.	Contact to 300									
Temperature, °F.	Room to 250, depending on catalyst									
Time, min.	Hot curing: 3-15 min. Cold curing: ½-6 hr.									

PROPERTY	AMERICAN ALKYD INDUSTRIES, Broad and 14th Sts., Carlstadt, N. J.								
Resin number	Amester 382	Amester 552	Amester 622	Amester 722	Amester 722 L.S.	Amester 852	Amester 922	Amester 1143	Amester 1254
Identity	Rigid, high viscosity. Button molding	Styrene: Matched metal polyester	Styrene: Casting buttons	Styrene: General-purpose	Styrene: Light stabilized sheet resin	Fire Retardant Polyester	Flexible Polyester	Thixotropic pre-accelerated boat resin	Thixotropic pre-accelerated all-weather
Viscosity at 25° C., cp.	To 25,000	1100	1600	600	600	3000	250	4500	3250
Storage life of resin at 77° F.	3 mo.	4 mo.	4 mo.	6 mo.	6 mo.	6 mo.	6 mo.	2 mo.	6 mo.
Resin content as applied, %	100% reactive	73	70	70	70	75	75	65	75
Storage life of treated material	1% benzoyl peroxide – 2-5 days								
Curing cycle									
Pressure, p.s.i.	Contact and up								
Temperature, ° F.	Room temperature to 280 depending on type and concentration of catalyst and promoter								
Time, min.	30 sec. and up depending on temperature, pressure, catalyst, promoter, and resin mass								

PROPERTY	FREEMAN CHEMICAL CORP., Pt. Washington, Wis., a subsidiary of H. H. Robertson Co.								LOVEN CHEMICAL OF CALIFORNIA, Newhall, Calif.
Resin number	Stypol 16B	Stypol 25	Stypol 4051	Stypol 407	Stypol 405	Stypol 100S	Stypol 12	Stypol 912	Loven LLR 26044
Identity	VHHDT rigid polyester	VHHDT rigid polyester	Resilient polyester	HHDT rigid polyester	Rigid polyester	Light stabilized rigid polyester	Flexible polyester	Thixotropic resin for Rand gun	Phenolic resin
Viscosity at 25° C., cp.	10,000-20,000	3000-5000	1500-1800	1500-1800	900-1200	2000-2500	600-900	600 at 30 r.p.m.	300-500
Storage life of resin	77° F.: > 3 mo. 40° F.: > 1 yr.							–	Room temp.: 2 mo. <60° F.: 5 mo.
Resin content as applied, %	30 to 60							–	30-50
Storage life of treated material	77° F.: 5 days, except Stypol 114 which is 2-3 days. 100° F.: several hr.							–	<70° F.: 6 mo.
Curing cycle									
Pressure, p.s.i.	Contact to 100							–	Contact and up
Temperature, ° F.	180 to 250, depending on catalyst. Room temperature cure possible with promoters.							–	300-350 on one side
Time, min.	1/8": 3-30, depending on temperature and catalyst							–	3-15

PROPERTY	MOL-REZ DIV., AMERICAN PETROCHEMICAL CORP., 3134 California St., N. E., Minneapolis 18, Minn.							
Resin number	Pleogen 1005	Pleogen 1100	Pleogen 1300	Pleogen 1300-LS	Pleogen 1405	Pleogen 1501	Pleogen 1700	Pleogen 1800
Identity	Rigid, medium viscosity for bag and matched die molding	Rigid, general purpose, hand lay-up	Rigid, general purpose	Rigid, light stabilized for sheeting, etc.	Flexible, low cost to improve impact resistance	Resilient for matched die molding	Rigid, high viscosity overlay resin	Rigid, thixotropic to prevent drainage
Viscosity at 25° C., cp.	650-800	330-380	2000-2500	2000-2500	350	2000-2500	45,000-75,000	grease-like
Storage life	6 mo. min.							3 mo.
Resin content	100% reactive							
Curing cycle								
Pressure, p.s.i.	Contact to 500							
Temperature, ° F.	Room temperature to 250° F., depending on catalyst system							
Time, min.	2 min. to 24 hr., depending on temperature and catalyst system							

PROPERTY	MOL-REZ DIV., AMERICAN PETROCHEMICAL CORP., 3134 California St., N. E., Minneapolis 18, Minn.							
Resin number	Pleogen 1810-3	Pleogen 1816-3	Pleogen 1834	Pleogen 1828	Pleogen 1870-2	Pleogen 2048-2	Pleogen 2055-2	Pleogen 2432
Identity	Rigid, fast-wetting thixotropic, hand layup	Rigid, thix. non-air-inhibited	Rigid, thix. air-inhibited	Resilient, thix. non-air-inhibited	Rigid, spray, thixotropic, for gun application	White gel coat	Translucent, neutral color gel coat	Chemical and steam resistant
Viscosity at 25° C., cp.	500-1100	500-1100	500-1100	500-1100	550-1300	5000-35000	5500-42000	1000
Storage life	3 mo.	1 mo.	1 mo.	3 mo.	3 mo.	1 mo.	1 mo.	3-6 mo.
Resin content	100% reactive							
Curing cycle								
Pressure, p.s.i.	Contact to 500							
Temperature, ° F.	Room temperature to 250° F., depending on catalyst system							
Time, min.	2 min. to 24 hr., depending on temperature and catalyst system							

PROPERTY	AMERICAN CYANAMID CO., 30 Rockefeller Plaza, New York 20, N. Y.							ATLAS POWDER COMPANY Wilmington 99, Del.	
Resin number	Laminac 4101, 4104, 4105, 4106, 4107, 4109, 4111, 4116, 4119, 4120, 4123, 4128 General purpose	Laminac 4103 Resilient	Laminac 4134 Flexible	Laminac 4146 Fire resistant	Laminac 4192 Light stable	Laminac 4202 Non volatile	Laminac 4232, 4233 High heat resistant	Atlac 382. Chemical resistant	Atlac FP. Fire-resistant
Indentity	Styrene modified					Diallyl phthalate modified	Tri-allyl cyanurate modified	Unsaturated polyester resin (solid)	
Viscosity at 25° C., cp.	175-25000	2200	300	3500	2500	13500	2500	In 35% styrene: 8000. In 50% styrene: 500	In 30% styrene: 4000
Storage life	Greater than 3 mo. at 77° F.							Indefinite	
Resin content	100% reactive							100 (as supplied)	
Storage life of treated material	From hours to days, depending on type of catalyst, catalyst concentration, type of resin, and temperature of storage							Room temperature: 1 day up to 6 mo.	
Curing cycle									
Pressure, p.s.i.	From contact to several hundred							Contact to 100	
Temperature, ° F.	From room temperature to 300 depending on catalyst-promoter system					200-300	180-500	Room to 320, depending on catalyst	
Time, min.	From 30 sec. to 30 min. at hot-press temperature several hours at room temperature					2-20	1-3 hr.	1 min. up to 30 min., depending on conditions	

PROPERTY	SYNCO RESINS, INC., Bethel, Conn.				SYNVAR CORP., Wilmington 99, Del.			
Resin number	Synco 269	Synco 274	Synco 4180	Synco 350	Synvaren LP	Synvaren 621	Synvaren 9203	Synvaren 9205, 9207
Identity	Modified phenolic resin	Phenolic resin	Modified phenolic resin	Phenolic resin	Straight phenolic resin			Modified phenolic resin
Viscosity at 25° C., cp.	250-280	195-315	145-245	100-250	300-500	8000-10,000	200-300	300-500
Storage life of resin	Below 50° F.: 6 months minimum				6 months to 1 year		6 mo.	6 mo. min.
Resin content as applied, %	30-50				30-50			30-50
Storage life of treated material	Room temp.: 3-12 months		Synco 4180: indefinitely long shelf life		4-6 months			Up to 6 mo.
Curing cycle								
Pressure, p.s.i.	50 and up				50 and up			50 and up
Temperature, ° F.	280-310				300 and up			275-350
Time, min.	Varies with thickness				Depends on conditions			

PROPERTY	CELANESE CORPORATION OF AMERICA, Plastics Div., 744 Broad St., Newark, N.J.										
Resin number	MR-28V MR-28C MR-28H	MR-28VS MR-28CS	MR-30V MR-30C	MR-31V MR-31C	Marcothix resins	MR-33V MR-33C MR-33H	MR-36R	MR-37C	MR-40R	MR-41R	MR-42R
Identity	Unsaturated polyester resin										
Viscosity at 25° C., cp.	V: 50 C: 600 H: 8,000	VS: 50 CS: 600	V: 30 C: 300	V: 50 C: 600	Thixotropic	V: 600 C: 2,000 H: 35,000	2000	600	2000	2000	2000
Storage life of resin	No catalyst, 70° F.: 6 mo.						No catalyst, 70° F.: 3 mo.				
Resin content as applied, %	47-75								70		
Storage life of treated material	40° F.: 1-2 wk. 70° F.: 4-6 da.	40° F.: 3-4 wk. 70° F.: 1-2 wk.	40° F.: 1-2 wk. 70° F.: 4-6 da.	40° F.: 3-4 wk. 70° F.: 1-2 da.	40° F.: 1-2 wk. 70° F.: 4-6 da.	40° F.: 3-4 wk. 70° F.: 1-2 wk.	40° F.: 2-3 wk. 70° F.: 3-5 da.	40° F.: 2-3 wk. 70° F.: 3-5 da.	40° F.: 1-2 wk. 70° F.: 3-5 da.		
Curing cycle											
Pressure, p.s.i.	Contact to 100 or higher								Contact to 500		
Temperature, ° F.	200-320 depending on catalyst. Room temperature curing with Marco Accelerators D and E.										
Time, min.	1 to 30, depending on catalyst, temperature, and pressure.										

PROPERTY	SCHENECTADY VARNISH CO., INC., Congress and 9th St., Schenectady 1, N. Y.									
Resin number	Isolite 703 Potting or encapsulation	Isolite 710 Hand layup	Isolite 720 General purpose	Isolite 731 Rigid, heat resistant	Isolite 765 Hand layup and die molding	Isolite 772 and 775 Resilient, high impact, low rigidity	Isolite 774 Resilient, medium rigidity	Isolite 777 Resilient, high rigidity	Isolite 750 Fire retardant	Isolite 780 Flexible
Identity	Polyesters									
Viscosity at 25° C., cp.	165-200	2900-3200	2900-3200	800-1000	Thixotropic	2200-2700 2000-2400	2000-2400	2100-2300	1800-2200	2900-3200

PROPERTY	NAUGATUCK CHEMICAL, Div. of U. S. Rubber Co., Naugatuck, Conn.								
Resin number	VIBRIN 114, 117, 152 General purpose	VIBRIN 151 Semi-rigid automotive	VIBRIN 152 LS-4 Light Stable	VIBRIN 156, 115A Matched die and Premix molding. High heat distortion	VIBRIN 121 Flexible	VIBRIN 157, 154 Compounded for hand layup, boats, etc.	VIBRIN 159, W943B Light wt. compounded for hand layup, boats, etc.	VIBRIN X-1109 Thixotropic for dual spray guns	VIBRIN X-1113 Light wt. thixotropic for dual spray guns
Identity	Unsaturated polyester styrene resins								
Viscosity at 25° C., cp.	114, 117: 1000 152: 2500	300 to 400	2500	115A: 1000 156: 2500	60	Thixotropic 400-1200	400	Thixotropic 900-3500	Thixotropic 900-3500
Storage life of resin	No catalyst, 70° F.; dark, 1 year; refrigerated, indefinitely								
Resin content as applied, %	100% polymerizable								
Storage life of treated material	1.5% benzoyl peroxide, 25° C., —> 48 hr. Refrigerated — 1 week to 1 mo.				Fast cure at room temperature				
Cure cycle									
Pressure, p.s.i.	Hand squeegee to 300								
Temperature, °F.	Room temperature to 300								
Time, min.	0.5 up depending on catalyst, temperature, promoter, etc.								

PROPERTY	NAUGATUCK CHEMICAL, Div. of U. S. Rubber Co., Naugatuck, Conn.			PLASTICS & COAL CHEMICALS DIV., ALLIED CHEM. CORP. 40 Rector St., New York 6, N.Y.			
Resin number	VIBRIN 135, 136A Super heat resistant 500° F.	VIBRIN A-601 Shellcoating semi-flexible (unpromoted)	VIBRIN D-604, D-805 Shellcoating semi-rigid (promoted)	Plaskon 911	Plaskon 920	Plaskon 941	Plaskon 951
Identity	TAC Type	Compounded, filled, unsaturated polyester-styrene resins for spray or brushing.		Rigid; high heat distortion; diallyl phthalate	Rigid; high heat distortion; diallyl phthalate	General purpose; rigid; styrene	General purpose; rapid impregnating; styrene
Viscosity at 25° C., cp.	135: 2500 136A: 25,000	Thixotropic —> 10000		165,000 at 30° C.	10,000	700	330
Storage life of resin	—	6 mo.		12 mo. at 70° F. in the dark		6 mo. at 70° F. in the dark	
Resin content as applied, %	—	60-75 (25-40 inert)		—			
Storage life of treated material	>48 Hrs. at 25° C.	10 min. to several hr. at 25° C. with MEK peroxide varied.		2 da. at 70° F. in the dark		5 da. at 70° F. in the dark	14 da. at 70° F. in the dark
Cure cycle							
Pressure, p.s.i.	—	Spray or brush applied		Contact and up			
Temperature, °F.	—	50-100		180-250	180-250	Depends on catalyst accelerator system	
Time, min.	—	10 to several hr.		1-30 min.	1-30 min.	Depends on catalyst accelerator system	

PROPERTY	PLASTICS AND COAL CHEMICALS DIV., ALLIED CHEMICAL CORP., 40 Rector St., New York 6, N. Y.							
Resin number	Plaskon 9404	Plaskon 9411	Plaskon 9441	Plaskon 942	Plaskon 9500	Plaskon 9510	Plaskon 9511	Plaskon 9600
Identity	Rigid; light stable; styrene	Rigid; medium viscosity; styrene	Rigid; light stable; styrene	General purpose; rigid; styrene	Resilient, high impact; styrene	Resilient; medium viscosity; styrene	Resilient; low viscosity; styrene	Flexible; high impact; high elongation; styrene
Viscosity at 25° C., cp.	2200	2700	2200	2200	800	2700	800	1000
Storage life or resin	4 mo. at 70° F. in the dark			6 mo. at 70° F. in dark	4 mo. at 70° F. in the dark			
Storage life of treated material	4 da. at 70° F. in the dark			7 da. at 70° F. in the dark	4 da. at 70° F. in the dark			7 da. at 70° F. in the dark
Curing cycle								
Pressure, p.s.i.	Contact and up							
Temperature, °F.	Depends on catalyst-accelerator system							
Time	Depends on catalyst-accelerator system							

PROPERTY	REICHHOLD CHEMICALS, RCI Building, White Plains, N. Y.					
Resin number	Plyophen 169, 5013, 5025, 5592	Polylite 8000, 8001, 8006, 8007, 8008 General purpose	Polylite 8100, 8109, 8016 General purpose, light stabilized	Polylite 8037, 8237 & 8173 (resilient) Surfacing resins, non-air inhibited	Polylite 8039, 8051 High heat resistant	Polylite 8063 Self-extinguishing
Identity	Phenolic resin	100% polymerizable unsaturated polyester styrene resins				
Viscosity at 25° C., cp.	169: 80-160 5013: 40-75 5025: 150-400	8000: 900 8001: 900 8006: 3200 8007: 300 8008: 3200	8016: 3200 8100: 2200 8109: 400	320-1900 8237: thixotropic	8039: 2700-3700 8051: 3300-4300	1750-2350
Storage life of resin	Below 70° F.: 2 mo. Below 50° F.: 6 mo.	No catalyst in dark: 40° F.: Over 1 year 77° F.: 3-6 mo. 100° F.: 3-4 weeks				
Resin content as applied, %	60-70	60-72	70-72	60-65	70-72	65-72
Storage life of treated material	Room temperature: 4-6 mo.	From a few minutes to as much as six months, depending on type of resin, catalyst or catalyst-accelerator system, and storage temperature				
Curing cycle Pressure, p.s.i.	169, 5025 & 5592: 15 & up 5013: 50 & up	From contact on hand layup to 300 on preform molding and 50 to 2000 on premix molding				
Temperature, ° F.	169, 5025: 275-325 5013 & 5592: 300-325	Room temperature to 200 on hand layup; 180 to 280 on matched die molding; 225-325 on premix molding				
Time	169 & 5025: 325°F.: 1/8": 3 min. 275°F.: 1/8": 20 min. 5013: 1/8": 10-12 min. 5592: 1/8": 20 min.	Hot cures: 1 to 30 min. Cold cures: 30 min. to 10 hr.		Depending on resin, catalyst system used, mass, and curing conditions		

PROPERTY	REICHHOLD CHEMICALS, RCI Building, White Plains, N. Y.					
Resin number	Polylite 8120 Flexible 8130	Polylite 8166, 8168, 8180, 8181 (vinyltoluene) 8182 8183 (vinyltoluene) Resilient	Polylite 8204, 8205, 8208, 8211, 8217, 8224 Open lay-up Thixotropic	Polylite 8400 General purpose, non-volatile	Epotuf 6130, 6131, 6140	Epotuf 6160 Flexible
Identity	100% polymerizable unsaturated polyester styrene resins			100% polymerizable. Diallyl phthalate monomer	Epoxy resins	Epoxy resin
Viscosity at 25° C., cp.	8120: 1050-1300 8130: 600-900	8166: 750-1050 8168: 2700-3700 8180: 2000-2500 8181: 2200-2700 8182: 2300-2600 8183: 2300-2600	8204: 400 8205: 525 8208: 575 8211: 450 8217: 1200 8224: 400	150,000-180,000	6130: 500-900 6131: 4000-5000 6140: 10000-14000	1500-2000
Storage life of resin	No catalyst in dark: 40° F.: Over 1 year 77° F.: 3-6 mo. 100° F.: 3-4 weeks			No catalyst in dark: 77° F.: 6-12 mo.	Room temperature: unlimited	Room temperature: unlimited
Resin content as applied, %	54-80	60-72	60-62	30-70	25-100	100% reactive solids
Storage life of treated material	From a few minutes to as much as six months, depending on type of resin, catalyst or catalyst-accelerator system, and storage temperature				20 min. to several hours with some hardeners; to unlimited with other types	8-10 hours, or more, depending on hardener
Curing cycle Pressure, p.s.i.	From contact on hand layup to 300 on preform molding and 50 to 2000 on premix molding				Contact and up	Contact and up
Temperature, ° F.	Room temperature to 200 on hand layup; 180 to 280 on matched die molding; 225-325 on premix molding				Room temp. to 350 depending on curing agent	190° F. - 250° F. and up depending on hardener
Time	Hot cures: 1 to 30 min. Cold cures: 30 min. to 10 hr.		Depending on resin, catalyst system used, mass, and curing conditions		Hot cures: 10-60 min. Cold cures: From less than 2 to 4 hours depending on hardener	250° F. - 2 hrs. 212° F. - 5-6 hrs. 190° F. - overnight

PROPERTY	B. I. P. CHEMICALS LIMITED, Popes Lane, Oldbury, Birmingham, Eng.					
Resin number	4110, 4116, 4120, 4123, 4128, 800, 803, 804 General purpose	805, 808, 813, 817 Thixotropic hand lay-up resins	4111 Chemical corrosion resistance	4134 Flexible	801, 802 Fire resistance	7669 High heat resistance
Identity	Styrene					TAC
Viscosity at 25° C., cp.	2.3-35	—	1.25-1.75	2.3	5-14	65
Storage life of resin	Greater than 6 mo. with cool storage.					
Curing cycle Pressure, p.s.i.	Contact or 5-1120 or higher.					
Temperature, °F.	Room temperature to 280 depending on catalyst and promotor used.					200-300
Time, min.	2-30 at elevated temperatures, up to several hr. at room temp.					

PROPERTY	FURANE PLASTICS, INC., Los Angeles 39, Calif.			SHELL CHEMICAL CORP., Plastics and Resins Div., 50 W. 50 St., New York 20 N. Y.	
Resin number	Lamojet	Epocast 2D, 2E, 2F	Epocast 17, 28 High temperature	Epon 820, 828, 1001, 1004, 1310	Epon 815, 820, 828, 834
Identity	Furan	Epoxy		Epoxy resins - Dry lay-up	Epoxy resins - Wet lay-up
Gardener viscosity 23° C., cp.	200 - 300	2D: 3000 2E: 4000 2F: 2500	4000	Can be adjusted	500-100,000 depending on grade of resin
Storage life of resin	Over 1 year	Over 1 year	6 mo.	Room temperature: unlimited	No catalyst, room temp.: indefinite. With catalyst: 0.5 - 8 hr., depending on ambient temp. and type of catalyst
Resin content as applied, %	100	35 - 60	35 - 60	25 - 35	25 - 50
Storage life of treated materials	1 hour to 1 day	Several hours	Approx. 30 days	Dicyandiamide at room temp.: unlimited. *m*-Phenylenediamine and Curing agent Z at room temp. 2-3 wk.; at 40° F.: 6 mo.	1 - 8 hr., depending on curing agent
Curing cycle					
Pressure, p.s.i.	Contact	Contact and up		Contact and up	
Temperature, ° F.	Room temperature	Room temperature	Start at 300-350 Overnight at 400	225-350, depending upon curing agent	60-350, depending on curing agent
Time, min.	–	2D: 16 hr. 2E: 20 hr. 2F: 20 hr.	Overnight	10-35 depending on cure temp. and curing agent	10-60, up to 2 days for 60 - 80° F. curing

PROPERTY	SPECIALTY RESINS CO., 2801 Lynwood Road, Lynwood, Calif.				
Resin number	DurOpol 104	DurOpol 109 Fire resistant	DurOpol 120	DurOpol 190 190°C. heat distortion temp. Light resistant	DurOpol 2894 CW Cold cure resin
Identity	Polyester-styrene	Polyester-styrene	Polyester-styrene	Polyester-styrene	Polyester-styrene
Viscosity at 25° C., cp.	2500 - 3200	900 - 1300	800 - 1200	1750 - 2300	600 - 800
Storage life of resin	70° F., dark: >3 mo.; 105° F., dark: 14 days	75° F., dark: >4 mo.; 105° F., dark: 14 days	75° F., dark: >4 mo.; 105° F., dark: 14 days	70° F., dark: >3 mo.; 105° F., dark: 14 days	70° F., dark: >3 mo.; 105° F., dark: 14 days
Resin content as applied, %	–	–	–	–	–
Storage life of treated material	70° F.: 36 hr. 100° F.: 6 hr. (1% benzoyl peroxide)	75° F.: 24 hr. 105° F.: 10 hr. (1% benzoyl peroxide)	75° F.: 30 hr. 100° F.: 15 hr. (1% benzoyl peroxide)	70° F.: 36 hr. 100° F.: 6 hr. (1% benzoyl peroxide)	–
Curing cycle					
Pressure, p.s.i.	Contact and up	Contact and up	Contact and up	Contact and up	Contact and up
Temperature, ° F.	Room temperature to 275, depending upon catalyst and promoter used				
Time, min.	1/16": 2 1/8": 4 1/4": 8 (at 50 p.s.i.)	1/8": 15-20 1/4": 30-40 1/2": 45-55 (at 30 p.s.i.)	1/8": 20-30 1/4": 40-50 1/2": 60-70 (at 30 p.s.i.)	1/8": 15-20 1/4": 30-45 1/2": 45-75 (contact to 50 p.s.i.)	Depends on temp. and amount of catalyst

PROPERTY	DURÉZ PLASTICS DIV., HOOKER CHEMICAL CORP., N. Tonawanda, N. Y. (see also p. 545)				
Resin number	Hetron 31 Resilient, tough, molding, potting	Hetron 32A Resilient, automotive, matched die	Hetron 72 Rigid, chemical resistance, high heat distortion	Hetron 92 Rigid, general purpose	Hetron 93LS Light stabilized
Identity	Fire resistant, unsaturated polyester resins, styrene monomer				
Viscosity at 25° C., cp.	1500-1800	2100-2900	2100-2900	2100-2900	900-1100
Storage life of resin	In dark at 73° F. — 6 mo.				
Resin content as applied, %	50-100	50-70	30-70	30-70	60-80
Storage life of treated material	1% benzoyl peroxide 3 days at 73° F.				
Curing cycle					
Pressure, p.s.i.	Contact to 500, not air inhibited				
Temperature, ° F.	60 to 300 depending on catalyzation time				
Time, min.	30 sec. to several days depending on catalyzation and temperature				

PROPERTY	COLUMBIA SOUTHERN CHEMICAL CORP., 1 Gateway Center, Pittsburgh 22, Pa.	CHEMICAL DEVELOPMENT CORP., Danvers, Mass.
Resin number	Allyl diglycol carbonate	Cepox 501 and 502 series
Identity	Allyl resin	Epoxy
Viscosity at 25° C., cp.	19.5 at 25° C. 6.4 at 70° C.	2000
Storage life of resin	No catalyst: several months: with catalyst: approx. 2 wk.	Indefinite prior to catalyst addition
Resin content as applied, %	40	100% reactive
Storage life of treated material	Room temp.: approx. 2 wk.	2-6 hr.
Curing cycle Pressure, p.s.i.	1-5	Contact and up
Temperature, ° F.	Start at 158. Raise slowly to 238.	Room to 200
Time, min.	1/8": 4-6 hr. 1/2": 6-8 hr.	6 hr. at room; 1 hr. at 20

PROPERTY	AMERICAN REINFORCED PLASTICS COMPANY, 851 E. 60th St., Los Angeles 1, Calif.	
Resin number	CTL-91-LD	37-9X
Identity	Phenolic	Phenyl silane
Viscosity at 25° C., cp.	Can be adjusted	
Storage life of resin	Must be refrigerated	
Resin content as applied, %	30-40	35-45
Storage life of treated material	Room temp. 1 mo. to indefinite. Refrigerated: indefinite	
Curing cycle Pressure, p.s.i.	Vacuum and up	
Temperature, ° F.	280 plus post-cure	
Time, min.	30 plus post-cure	

PROPERTY	ALKYDOL LABORATORIES, INC., Chicago 50, Ill.	TECHNICRAFT CO., 1156 Commonwealth Ave., Boston 34, Mass.
Resin number	Alk-O-Flex 452	Chemiglas Casting, embedding
Identity	Epoxy resin	Styrene polyester resin
Viscosity at 25° C., cp.	9850	Adjustable
Storage life of resin	–	No catalyst 40°F.: >1 yr. 77°F.: >9 mo. (in container)
Resin content as applied, %	–	50-75
Storage life of treated material	–	1% catalyst: 10 hr.
Curing cycle Pressure, p.s.i.	0-75 and up	Contact to 200
Temperature, ° F.	–	–
Time, min.	–	24-48 hr. with 1% cat.; 30-40 min. with 1% cat. & promoter; (small castings)

PROPERTY	DUREZ PLASTICS DIV., HOOKER CHEMICAL North Tonawanda, N. Y. (see also p. 544)	IRONSIDES RESINS, INC., 270 West Mound Street, Columbus, Ohio		PLASTICS ENGINEERING CO., Sheboygan, Wis.
Resin number	Durez 12120 16044	101	105 B4	Plenco 204 205
Identity	Phenolic resin	Phenolic	Phenolic	Phenolic resin
Resin or resin formers %	70 as shipped 16044: 60-65	68-72	64-67	204: 71-74 205: 67-70
Viscosity at 25° C., cp.	300-500 Can be adjusted	100-200	300-450	204: 400-600 205: 250-400
Solvents	Ethyl or isopropyl alcohol	Ethyl or isopropyl alcohol		Ethyl or isopropyl alcohol
Storage life of resin	Room temp.: 1 mo. Below 50° F., 3 mo.	Room temp.: 1 mo. Below 40° F., 3 mo.	Below 30° F., 3 mo. Must be refrigerated	Below 75° F., 2 mo.
Resin content as applied, %	30 to 50	20-40	30-45	30-50
Catalysts	–	–	–	–
Inhibitors	–	–	–	–
Impregnation apparatus	Conventional dip tank	Dip tank and squeeze rolls preferred	Dip tank and squeeze rolls preferred	Conventional dip tank with squeeze rolls or scraper bars
Preparation of resin	Adjust to desired viscosity and solids content with alcohol	As is for best results. Can be cut with alcohol	As is for best results. Can be cut with alcohol	Thin to desired viscosity and solids content with alcohol
Drying	Start at 200° F. Raise to 250-275° F. Adjust to give required volatile content	240°-260° F.: 3-5 min. Adjust speed for required volatile content	240°-250° F.: 3-5 min. dwell for vacuum molding. 270°-280° F.: 4-6 min. dwell for 100-300 p.s.i.	250-295°F. Adjust speed for desired volatile content
Storage life of treated material	Below 75° F.: Up to 6 mo.	If properly packaged and refrigerated, 6 mo.	If properly packaged and refrigerated, 6 mo.	Room temp.: 2 mo.
Curing cycle Pressure, p.s.i.	60-100. 16044: contact and up	Vacuum to 300	Vacuum to 300	100 and up
Temperature, ° F.	340 Heat supplied on one side	260 plus post cure	260 plus post cure	300-330
Time, min.	0.05" to 0.10": 10-15	30-45 at temp.	30-45 at temp.	1/8": 10-30

PROPERTY	UNION CARBIDE PLASTICS CO., DIV. OF UNION CARBIDE CORP., 420 Lexington Ave., New York 17, N. Y.			DOW CORNING CORP., Midland, Mich.					GENERAL ELECTRIC CO., 1 Plastics Ave. Pittsfield, Mass. (See also p. 537)	SILICONES DIVISION, UNION CARBIDE CORP., 30 E. 42nd Street, New York 17, N.Y.	
Resin number	Bakelite BLL-3085, 3238, 3526	Bakelite ERL-2774, ERL-2795, ERL-3794	Bakelite ERL-2774, EKR-2002, EKS-2002, EKR-2003, ELS-3001	Dow Corning 2104	Dow Corning 2106	Dow Corning 7141	Dow Corning R-7145	Dow Corning R-7146	GE 12304 GE 12389	Union Carbide R-640	Union Carbide XR-70
Identity	Phenolic resin	Epoxy resin, Wet lay-up	Epoxy resin, Dry lay-up	Silicone resins					Phenolic	Silicone resin	Silicone resin
Resin or resin formers, %	3238: 73-78 3085: 61-65 3526: 63½-67½	100	69-100	60	60	60	100	100	70	65	100
Viscosity at 25° C., cp.	3238: 1500-2500 3085: 125-175 3526: 210-340	500-19,500	Can be adjusted	20 to 40	30 to 50	20	2200	130	12304: 200-300 12389: 150-200	20-40 cst.	250-350 cps.
Solvents	Ethyl alcohol, alcohol and water mixtures	Ketones, esters, aromatics and alcohol-ethers	Ketones, esters, aromatics and alcohol-ethers	Toluene or naphthas of b.p. < 200° F.			None required		Ethyl or isopropyl alcohol	Toluene, benzene, acetone, xylene, or isopropanol	None required
Storage life of resin	3238: Below 70° F.-60 da. Below 50° F.-6 mo. 3526: Below 50° F.-3 mo.	No hardener, room temperature: indefinite	Room temperature, unlimited	No catalyst: > 6 mo.			> 12 mo.		Below 75° F. 60 days	Uncatalyzed:	> 12 mo. 4 mo.
Resin content as applied, %	3238: 35-60 3085: 28-44 3526: 35-60	50-80	30-40	60	60	60	100	100	30-50	65	100
Catalysts	Can be accelerated by 1% NaOH or hexamethylene tetramine	22½ p.p.h. ZZL-0812 37½ p.p.h. ZZL-0803 25 p.p.h. ERL-2793	Benzyl dimethyl amine; aromatic amines; diaminodiphenylsulfone; anhydrides	DC XY-5 10-25 cc./gal.	DC XY-15 0.1 to 0.3%	DC XY-15 (1.5-3.5 mil/lbs. solution)	3% dicumyl peroxide		None necessary	RC-640 Catalyst -2.0 to 6.0 gm. catalyst per pound of resin solids	0.9% Ditertiary butyl peroxide or 1.5% dicumyl peroxide
Inhibitors	Acids to narrow pH range	None	None	Acids			Usual peroxides		—	None	None
Impregnation apparatus	Dip tank with squeeze rolls or scraper bars	Pour-on, knife coating, brush squeeze rolls	Dip tank with rolls or bars. Drying oven	Dip tank, hot-air curing oven			Wet lay-up		Dip tank with or without squeeze rolls	Conventional dip tank	Wet lay-up vacuum bag, and contact pressure press techniques
Preparation of resin	Thin resin to viscosity desired for treating	Add hardener or catalyst, agitate at room temperature	Add hardener or catalyst, agitate at room temperature	Add catalyst and agitate thoroughly. Apply to heat-cleaned or properly finished cloth			Add catalyst, mix, apply		Thin if necessary to obtain proper resin pick-up	Add catalyst; agitate; apply	Add catalyst; agitate; apply
Drying	3238: 2 to 7 min. at 285° F. 3085, 3526: 5 to 6 min. at 260-280° F.	—	—	Precure for 5-10 min. at 230° F. Special postcure cycles for electrical and high-temperature uses			None		Dry at 250-275° F. Adjust speed to give required flow in material	6 minutes at 135° C. Adjust to give desired flow of material	No drying required
Storage life of treated material	Room temp.: 2 mo.	1/4 to 6 hr.	Benzyl dimethyl amine at room temp. (for ELS-3001) unlimited. Methylene dianilene at room temp. 1-4 weeks: at 40° F., 3-6 mo.	Resin solution with catalyst: 24 hr. at 77° F. Coated fabric: 6 mo. at 77° F.	Resin solution with catalyst: 30 da. at 77° F. Coated fabric: 6 mo. at 77° F.	Resin solution with catalyst: 30 da. at 77° F. Coated fabric: 2-3 mo.	Pot life of catalyzed resin > 6 mo. at some temperatures.		Room temp.: 2 mo.	85° F.: > 3 mo.	—
Curing cycle Pressure, p.s.i.	3238: 50-300 3085: 14-300 3526: 50-300	Contact to 300	Contact and up	3-30	15-200	10-200	Contact		15 and up	15 to 300	Contact
Temperature, °F.	240 to 360	Room to 325	300-375	347	347	347	300-350		320-330	For bag-molded lay-ups, 1 hr. at 250° F. and 1 hr. at 300° F.	300
Time, min.	1/8" 3238: 10-15 3085: 30-60 3526: 30-50	10 to 2 days	30-60	1/8": 15-30 1/4": 30-60 1/2": 60	1/8": 15-30 1/4": 30-60 1/2": 60		1 to 4 hr. Post-cure for special uses		1/8": 30	For matched-metal-molding techniques; 1 hr. at 350° F. Post-cure for certain applications	4 hrs.

Laminates Chart

PROPERTIES[a]	DIALLYL PHTHALATE LAMINATES		POLYESTER LAMINATES				VULCANIZED FIBRE *(in general, low thicknesses give high values)*
	Glass fabric base	*Cotton fabric base*	*Glass fabric base*	*Glass mat base*	*Paper base*	*Cotton base*	
1. Laminating temp., °F.	200-300	200-300	R.T.-300	R.T.-300	180-250	180-300	–
2. Laminating pressure, p.s.i.	10-1500	10-1500	0-50	10-150	0-10	0-10	–
3. Specific gravity, D792	1.65	1.38	1.5-2.1	1.5-1.9	1.2-1.5	1.2-1.4	0.9-1.5
4. Specific volume, cu. in. per lb., D792	16.8	20.1	18.5-13.2	18.5-14.4	23.0-18.5	23.0-19.7	30.0-18.5
5. Tensile strength, D638, p.s.i.	21000-29000	8500-10500	18000-55000	10000-20000	6100-14300	7000-9000	7000-14000
6. Modulus of elasticity in tension, D638, 10^5 p.s.i.	–	–	10-28	10-19	8-12	–	8-12
7. Compressive strength, D695, p.s.i.	45000	40000	30000-60000	30000-50000	19700-25000	23000-24000	20000-30000
8. Modulus of elasticity in compression, D695, 10^5 p.s.i.	–	–	30-40	–	–	–	–
9. Flexural strength, D790, p.s.i.	42000-50000	12000-17000	18000-80000	15000-35000	13000-28000	13000-18000	10000-20000
10. Modulus of elasticity in flexure, D790, 10^5 p.s.i.	–	–	10-30	10-18	8-13	5-12	7-10
11. Shear strength, D732, p.s.i.	17800-20000	14000-14700	12000-18000	10000-16000	–	–	–
12. Modulus of elasticity in shear, 10^5 p.s.i.	–	–	5-7	–	–	–	–
13. Bearing strength, D953, p.s.i.	–	–	40000-50000	–	–	–	–
14. Impact strength, Izod, D256, ft.-lb. per in. of notch	4.3-6.7	0.8-1.2	19-35	8-18	–	1.5-2.3	1.0-8.0
15. Bond strength, D952, lb.	1300	1100	2000-3000	850-1000	1000-2000	1000-1500	1000
16. Hardness, Rockwell, D785	M120	M110	M100-M110	M70-M105	–	M50-M90	R50-R100
17. Thermal conductivity, C177, 10^{-4} cal./sec./sq. cm./1°C./cm.	–	6.3-6.6	–	1.7-2.0	–	–	3-5
18. Specific heat, cal. per °C. per gm.	–	–	0.25-0.26	–	–	–	0.4
19. Thermal expansion, D696, 10^{-5} per °C.	–	–	–	2.0-2.2	3.1	–	2.3
20. Resistance to heat (continuous),[b] °F.	300	–	200-400	250-300	220-250	250	225
21. Heat distortion temp., D648, °F.	–	–	–	–	240	–	–
22. Insulation resistance (96 hr. at 90% R.H. and 35°C.), D257, megohms	150	–	–	100-50000	–	–	–
23. Volume resistivity (50% R.H. and 25°C.), D257, ohm-cm.	–	–	–	10^6-10^{12}	10^{13}	–	–
24. Dielectric strength, short-time, 1/8-in. thickness, D149, volts per mil	530	390	200-700	500-600	600-800	300-500	150-250
25. Dielectric strength, step-by-step, 1/8-in. thickness, D149, volts per mil	–	–	220-600	200-450	400-600	270-400	125-225
26. Dielectric strength, step-by-step, ‖ to lamination, KV/in.	75	40	45-50	40-85	40-60	–	–
27. Dielectric constant, 60 cycles, D150	4.3	5.1	4.0-6.0	4.0-5.0	5.1	–	–
28. Dielectric constant, 10^3 cycles, D150	–	–	–	4.2-5.0	–	–	4.7
29. Dielectric constant, 10^6 cycles, D150	4.1	4.8	3.0-4.0	4.0-4.9	3.0-4.2	2.9-3.6	
30. Dissipation factor, 60 cycles, D150	0.013	0.015	0.02-0.04	0.005-0.05	0.1	–	–
31. Dissipation factor, 10^3 cycles, D150	–	–	–	0.004-0.04	–	–	0.03-0.08
32. Dissipation factor, 10^6 cycles, D150	0.015	0.018	0.007-0.03	0.007-0.04	0.02-0.03	0.02-0.04	
33. Arc resistance, D495, sec.	150	130	80-140	100-130	28-75	70-85	110-150
34. Water absorption, 24 hr., 1/8-in. thickness, D570,%	0.12	0.60	0.2-2.5	0.2-0.8	0.5-1.5	1.3-1.6	18-65
35. Burning rate, D635	–	–	Slow to nil	Slow to nil	Moderate to self-extinguishing		Slow
36. Effect of sunlight	Nil	Nil	Approx. nil	Approx. nil	Slight darkening		Slight
37. Effect of weak acids, D543	None	None	None	None	None	None	Embrittled by some
38. Effect of strong acids, D543	Slight	Decomposes	Some attack	Some attack	Some attack	Some attack	Embrittled
39. Effect of weak alkalies, D543	None	None	Slight to none	Slight to none	Slight	Slight	Swells
40. Effect of strong alkalies, D543	Slight	Attacked	Some to severe	Some to severe	Attacked	Attacked	Swells
41. Effect of organic solvents, D543	None	None	Generally nil	Generally nil	Generally nil	Generally nil	None
42. Machining qualities	Fair	Good	Fair	Good	Excellent	Excellent	Good to excellent
43. Trade designations (see list of manufacturers on page 551 for key to numbers)	Conolite (6), Dilecto (7), Dryply (13), du Verre (9), Formica (14), Gillfab, Gillab, and Gillite (16), Glastic (17), Iolyte (34), Kevinite (36), Lamidall (41), Lamin-Art (11), Micarta (39), Panelyte (27), Phenolite (24), Repcoboard (32), Sunform (10), Swedlow (36), Synthane (37), Trevarno (4), Tropiglas (32), Wallfab (16), Zenaloy (39)						Diamond (7), Duroid (31), National (24), Peerless (24), Spaulding (35), Taylor (38), Vulcoid (7), Wilmington (40)
44. Manufacturers (See list on page 551 for key to numbers)	4, 6, 7, 9, 11, 13, 14, 16, 17, 20, 24, 27, 32, 34, 36, 37, 39, 41, 42						7, 24, 31, 35, 37, 38, 40

Footnotes are on p. 551

PROPERTIES[a]	EPOXY LAMINATES		MELAMINE-FORMALDEHYDE LAMINATES				
	Glass fabric base	*Cellulose paper base*	*Cellulose paper base*	*Cotton fabric base*	*Asbestos paper or fabric base*	*Glass fabric base*	*Glass mat*
1. Laminating temp., °F.	R.T. - 370	250-300	270-320	260-320	270-320	270-300	270-320
2. Laminating pressure, p.s.i.	10-1800	600-1000	1000-1800	1000-1500	1000-1800	1000-1800	1000-1800
3. Specific gravity, D792	1.7-1.9	1.3	1.40-1.55	1.35-1.5	1.75-1.85	1.82-1.98	1.75-1.85
4. Specific volume, cu. in. per lb., D792	16.3-14.5	18	19.1-17.8	20.5-18.5	15.8-14.9	15.2-13.9	16.9-15.0
5. Tensile strength, D638, p.s.i.	33000-65000	19000	10000-25000	7000-15000	6000-12000	25000-40000	16000-25000
6. Modulus of elasticity in tension, D638, 10^5 p.s.i.	25-35	7-12	–	10-19	16-22	20-25	–
7. Compressive strength, D695, p.s.i.	50000-100000	28000	30000-48000	33000-46000	27000-50000	30000-85000	60000
8. Modulus of elasticity in compression, D695, 10^5 p.s.i.	–	–	–	–	–	47	–
9. Flexural strength, D790, p.s.i.	45000-80000	19000	14000-20000	14000-26000	12000-24000	40000-65000	21000-30000
10. Modulus of elasticity in flexure, D790, 10^5 p.s.i.	20-50	10-13	–	–	–	15-30	13
11. Shear strength, D732, p.s.i.	17000-22000	12200	–	16500-18000	13000-17000	19000-35000	–
12. Modulus of elasticity in shear, 10^5 p.s.i.	–	–	–	–	–	–	–
13. Bearing strength, D953, p.s.i.	–	–	–	–	–	–	–
14. Impact strength, Izod, D256, ft.-lb. per in. of notch	10-25	0.75	0.3-1.5	0.5-1.7	0.75-4	5-15	5-6.5
15. Bond strength, D952, lb.	1600-2700	1200	1000	1500-2500	800-1500	1500-2300	1400-2000
16. Hardness, Rockwell, D785	M105-M120	M109	M110-M125	M110-M120	M110-M118	M115-M125	M115-M125
17. Thermal conductivity, C177, 10^{-4} cal./sec./sq. cm./1°C./cm.	7.1-7.4	–	–	–	–	12	–
18. Specific heat, cal. per °C. per gm.	–	–	–	–	–	0.23-0.26	–
19. Thermal expansion, D696, 10^{-5} per °C.	1.0-1.2	–	–	0.7-2.5	–	0.7-1.2	–
20. Resistance to heat (continuous),[b] °F.	250-300	300	210-260	210-260	225-275	300	290
21. Heat distortion temp., D648, °F.	355-375	275	–	–	–	–	–
22. Insulation resistance (96 hr. at 90% R.H. and 35°C.), D257, megohms	50000-100000	150000	–	100-5000	5	30-1500	10-500
23. Volume resistivity (50% R.H. and 25°C.), D257, ohm-cm.	1×10^{13}	7×10^{15}	–	–	–	–	–
24. Dielectric strength, short-time, 1/8-in. thickness, D149, volts per mil	400-750	540-600	400-700	200-450	50-150	200-500	300-450
25. Dielectric strength, step-by-step, 1/8-in. thickness, D149, volts per mil	300-600	4[illegible]0-540	200-450	150-350	60-120	150-350	250-350
26. Dielectric strength, step-by-step, ‖ to lamination, KV/in.	35-110	60-80	–	12-65	7	35-75	35-55
27. Dielectric constant, 60 cycles, D150	4.2-6.5	4.5	–	7.5-8.6	–	6.5-10.0	4.5-6.5
28. Dielectric constant, 10^3 cycles, D150	–	–	7.9	7.3-8.3	–	6.1-9.5	4.2-6.0
29. Dielectric constant, 10^6 cycles, D150	4.5-5.3	4.35	6.4-8.5	6.2-8.0	8.0-9.6	6.0-9.0	4.2-7.5
30. Dissipation factor, 60 cycles, D150	0.003-0.015	0.004	–	0.06-0.15	–	0.04-0.10	0.004-0.05
31. Dissipation factor, 10^3 cycles, D150	–	–	0.057	0.03-0.09	–	0.012-0.03	0.004-0.05
32. Dissipation factor, 10^6 cycles, D150	0.010-0.025	0.0300	0.035-0.05	0.03-0.07	0.12-0.22	0.011-0.025	0.006-0.08
33. Arc resistance, D495, sec.	15-180	10	100	120-175	–	175-200	170-200
34. Water absorption, 24 hr., 1/8-in. thickness, D570, %	0.05-0.30	0.15	1.0-2.0	1.0-2.0	1.0-5	1.0-2.5	1.25-2.8
35. Burning rate, D635	Slow to nil	Slow	Approximately nil			Nil	Nil
36. Effect of sunlight	Slight color change		Slight color change				–
37. Effect of weak acids, D543	None		Slight to marked	Slight to marked	None	None	None
38. Effect of strong acids, D543	Slight		Decomposes				
39. Effect of weak alkalies, D543	None		None	None	None	None	None
40. Effect of strong alkalies, D543	Slight		Attacked	Attacked	None	Attacked	Attacked
41. Effect of organic solvents, D543	Slight to none	–	None on bleed-proof materials				
42. Machining qualities	Good	Excellent	Fair	Fair	Fair	Fair	Fair
43. Trade designations (See list of manufacturers on p. 551 for key to numbers)	Dilecto (7), Formica (14), Gillfab (16), Helix (1), Insurok (30), Lamicord (22), Lamin-Art (11), Nelco (25), Norplex (26), Phenolite (24), Renite (43), Repcoboard (32), Sunform (10), Swedlow (36), Synthane (37), Taylor (38), Textolite (15), Trevarno (4)		Aqualite (24), Celoron (7), Consoweld (5), Decarlite (8), Dilecto (7), Farlite (12), Formica (14), Hi-Den (28), Lamicoid (22), Lamin-Art (11), Micarta (39), Norplex (26), Ohmoid (40), Panelyte (27), Phenolite (24), Pionite (29), Pregwood (14), Resilyte (2), Ryertex (33), Spauldite (35), Synthane (37), Taylor (38), Tensilite (19), Textolite (15)				
44. Manufacturers (See list on p. 551 for key to numbers)	1, 4, 7, 9, 11, 14, 15, 16, 22, 24, 26, 30, 32, 36, 37, 38, 42, 43		2, 3, 5, 7, 8, 11, 12, 14, 15, 18, 19, 22, 24, 26, 27, 28, 29, 30, 33, 35, 37, 38, 39, 40				

Footnotes on p. 551.

	PHENOL-FORMALDEHYDE LAMINATES							
	Cellulose paper base	*Cotton fabric base*	*Cotton web base*	*Nylon fabric base*	*Glass fabric base*	*Asbestos fabric base*	*Asbestos paper base*	*Wood base*
1.	275-350	275-350	275-350	275-325	275-350	300-350	300-350	300-320
2.	1000-1800	1000-1800	1000-1800	1000-1800	50-2000	1000-1800	1000-1800	1000-2000
3.	1.28-1.40	1.30-1.36	1.31-1.37	1.15-1.19	1.4-1.8	1.55-1.80	1.65-1.83	1.3
4.	21.8-19.7	21.3-20.4	21.1-20.2	24.0-23.2	19.7-15.4	17.8-15.4	16.8-15.1	21.3
5.	8000-20000	9000-16000	14000-16000	5000-9500	9000-43000	10000-12000	5000-15000	16000-32000
6.	8-20	5-15	6-11	3.6	15-25	3.5-15	–	37
7.	20000-40000	30000-44000	32000-47000	28000-36000	34000-67000	30000-40000	40000	12000-21000
8.	8	6	4-8	–	–	7	5	–
9.	10500-30000	16000-30000	18000-25000	9000-22000	20000-85000	10000-35000	15000-30000	25000-40000
10.	8-15	8-10	6-10	7-10	15-25	12	–	–
11.	9000-14000	14000-18000	12600-14000	10000-13700	17200-24000	19000-21000	9000-13500	–
12.	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–
14.	0.3-1.0	1.0-2.5	1.4-2.5	2.0-4.0	4.0-10.0	3.5-5.0	0.7-1.9	4-8
15.	700-1400	1200-2500	1000-1600	1000-1500	800-1600	1500-2200	600-2000	–
16.	M70-M120	M90-M115	M100-M110	M100-M110	M105-M110	M70-M115	M90-M110	M90-M105
17.	1.8	2.1-2.3	–	–	1.4-1.8	4.6	–	–
18.	0.38-0.41	0.35-0.38	–	–	0.23-0.27	–	–	0.2-0.4
19.	1.4-3.0	1.8-3.2	1.3-1.6	4	1.5-2.5	1.7-2.5	1.0-1.6	0.6 ∥, 6.5 ∥
20.	225-250	225-250	225	165	250-300	275	275	150-200
21.	250->320	>320	>320	165	>320	>320	>320	>320
22.	35-1,000,000	10-5000	5-200	30000-500000	25-5000	–	–	0.25-335
23.	10^{10}-10^{13}	10^{10}-10^{12}	–	7×10^{13}	2.5×10^{10}	–	–	–
24.	300-1000	150-600	200	360-600	300-900	50-100	160-250	75-500
25.	260-800	120-440	150	300-450	250-700	50-75	120-200	–
26.	15-70	10-60	10-40	40-100	30-50	5-15	4-25	–
27.	4.5-7.5	5.0-10	–	3.7-6.0	4.0-10.0	–	–	–
28.	4.2-6.0	4.2-6.5	–	3.6-4.1	4.8-6.3	7.5	7.0	–
29.	3.6-6.0	5.0-7.0	5.5-7.0	3.3-4.5	3.7-6.0	5.5-10.0	5.2	5
30.	0.02-0.10	0.04-0.50	0.10-0.5	0.02-0.06	0.01-0.10	–	–	0.20
31.	0.03-0.07	0.04-0.09	–	0.01-0.02	0.015-0.042	0.06-0.10	0.15-0.20	–
32.	0.02-0.08	0.05-0.10	0.06-0.50	0.015-0.040	0.01-0.05	0.10-0.15	0.08-0.14	0.05
33.	Tracks	Tracks	Tracks	Tracks	Tracks	Tracks	Tracks	Tracks
34.	0.2-4.5	0.8-2.0	1.2-1.6	0.15-0.35	0.3-1.5	0.3-2.5	0.4-2.0	2.5-11
35.	Very low	Very low	Very low	Slow	Nil	Approx. nil	Approx. nil	Very low
36.	**Lowers surface resistance and general darkening**							
37.	**None to slight depending on acid**							
38.	**Decomposed by oxidizing acids; reducing and organic acids none to slight effect**							
39.	**Slight to marked depending on alkalinity and grade**							
40.	**Attacked by strong alkalies unless a special alkali-resistant resin is used**							
41.	**None on bleed-proof materials**							
42.	Fair to excellent				Fair to good			Good
43.	**Aqualite (24), Capac (3), Celoron (7), Consoweld (5), Decarlite (8), Dilecto (7), Farlite (12), Formica (14), Gillfab (16), Hi-Den (28), Lamicoid (22), Laminart (11), Micarta (39), Nelco (25), Norplex (26), Ohmoid (40), Panelyte (27), Phenolite (24), Pregwood (14), Resilyte (2), Ryertex (33), Spauldite (35), Sunform (9), Swedlow (36), Synthane (37), Taylor (38), Tensilite (19), Textolite (15), Trevarno (4)**							
44.	2, 3, 4, 5, 7, 8, 11, 12, 14, 15, 16, 18, 19, 22, 25, 26, 27, 28, 29, 30, 31, 33, 35, 36, 37, 38, 39, 40, 42							

PROPERTIES[a]	TEFLON LAMINATES		SILICONE LAMINATES		LIGNIN PLASTIC	EPOXY LAMINATES
	Ceramic fiber base	*Glass fabric base*	*Glass fabric base*	*Asbestos fabric base*	*(Laminated)*	*Non-woven continuous glass filament base*
1. Laminating temp., °F.	–	–	430-480	350-400	275-365	250-330
2. Laminating pressure, p.s.i.	–	–	30-2000	30-2000	2000-2500	10-100
3. Specific gravity, D792	1.9-2.2	2.2	1.6-1.9	1.75	1.35-1.45	1.75-1.85
4. Specific volume, cu. in. per lb., D792	14.6-12.8	12.8	17.3-14.5	15.8	21.6-19.0	15.8-14.9
5. Tensile strength, D638, p.s.i.	1500-4000	12000-20000	10000-35000	–	5000-8000	110000
6. Modulus of elasticity in tension, D638, 10^5 p.s.i.	–	–	15-20	–	–	55
7. Compressive strength, D695, p.s.i.	–	20000	35000-46000	40000-50000	25000-30000	80000
8. Modulus of elasticity in compression, D695, 10^5 p.s.i.	–	–	–	–	–	–
9. Flexural strength, D790, p.s.i.	–	11000-13000	10000-38000	12000-16000	9000-15000	130000
10. Modulus of elasticity in flexure, D790, 10^5 p.s.i.	–	–	10-25	–	13	53
11. Shear strength, D732, p.s.i.	–	11000	16500-18000	–	–	–
12. Modulus of elasticity in shear, 10^5 p.s.i.	–	–	–	–	–	–
13. Bearing strength, D953, p.s.i.	–	–	–	–	–	–
14. Impact strength, Izod, D256, ft.-lb. per in. of notch	1.1-2.5	4-6	8-15	6-9	0.5-1.5	60.8
15. Bond strength, D952, lb.	–	600-900	600-1300	–	450-600	–
16. Hardness, Rockwell, D785	–	M60	M100	–	M90	M100-M108
17. Thermal conductivity, C177, 10^{-4} cal./sec./sq. cm./1°C./cm.	–	1-2	7	–	–	–
18. Specific heat, cal. per °C. per gm.	0.25	0.2	0.25-0.27	–	–	0.217
19. Thermal expansion, D696, 10^{-5} per °C.	3.7-3.8	–	0.5-1.0	–	0.42	0.9-2.5
20. Resistance to heat (continuous),[b] °F.	500	480	400-500	>480	150	325
21. Heat distortion temp., D648, °F.	> 500	–	500	> 400	–	350-400
22. Insulation resistance (96 hr. at 90% R.H. and 35°C.), D257, megohms	30	5000 to 10^6	100000-300000	–	–	52000
23. Volume resistivity (50% R.H. and 25°C.), D257, ohm-cm.	> 10^7	> 10^6	–	–	1.6 x 10^{12}	3.3 x 10^{13}
24. Dielectric strength, short-time, 1/8-in. thickness, D149, volts per mil	150-250	300-750	180-480	50-150	135 (¼ in.)	500-700
25. Dielectric strength, step-by-step, 1/8-in. thickness, D149, volts per mil	–	250-700	150-350	50-100	105 (¼ in.)	–
26. Dielectric strength, step-by-step, ǁ to lamination, KV/in.	–	50-70	25-60	–	–	36
27. Dielectric constant, 60 cycles, D150	2.5-2.7	2.6-2.8	3.7-4.3	–	6 (¼ in.)	5.9
28. Dielectric constant, 10^3 cycles, D150	–	2.6-2.8	3.7-4.3	–	–	5.6
29. Dielectric constant, 10^6 cycles, D150	2.4-2.5	2.6-2.8	3.7-4.3	–	–	5.4
30. Dissipation factor, 60 cycles, D150	0.002.0.003	0.0005	0.0005-0.0055	–	0.11	0.005
31. Dissipation factor, 10^3 cycles, D150	–	0.0004	0.0006-0.0035	–	–	0.007
32. Dissipation factor, 10^6 cycles, D150	0.001-0.003	0.0006	0.0015-0.003	–	–	0.018
33. Arc resistance, D495, sec.	190	180 +	150-250	–	135	–
34. Water absorption, 24 hr., 1/8-in. thickness, D570, %	0.5-2.0	0.02	0.085-0.65	1.0-1.5	2.5 (¼ in.)	0.05-0.1
35. Burning rate, D635	Nil	Nil	Very low	Nil	Slow	0.1 in./min.
36. Effect of sunlight	Nil	Nil	Nil	Nil	Slight	Slight
37. Effect of weak acids, D543	None	None	None	Very slight	None to slight	None
38. Effect of strong acids, D543	Attacked by HF only		Some attack	Some attack	Poor	Slight
39. Effect of weak alkalies, D543	None	None	Very slight	Very slight	Fair	Slight
40. Effect of strong alkalies, D543	Slight	Slight	Attacked	Attacked	Poor	Slight
41. Effect of organic solvents, D543	None	None	Attacked by some		Slight	Slight
42. Machining qualities	Fair to good	Good	Fair	Fair	Good	Excellent
43. Trade designations (see list of manufacturers on p. 551 for key to numbers)	Duroid (31)	Duroid (31) Lamicord (22) Phenolite (24)	Dilecto (7), Formica (14), Gillfab (16), Lamicoid (22), Lamin-Art (11), Micarta (39), Panelyte (27), Phenolite (24), Sunform (9), Swedlow (36), Synthane (37), Taylor (38), Textolite (15), Trevarno (4)		Benelex (21)	Scotchply (23)
44. Manufacturers (See list on p. 551 for key to numbers)	31	7, 22, 24, 31	4, 7, 9, 11, 14, 15, 16, 20, 22, 24, 27, 36, 37, 38, 39, 42		21	23

Footnotes are on p. 551

LIST OF MANUFACTURERS AND SUPPLIERS OF LAMINATES*

1. Biggs Co., Inc., Carl H., 2255 Barry Ave., Los Angeles 64, Calif.
2. Buckstaff Co., The, Oshkosh, Wis.
3. Capac Industries, Inc., S. Main St., Capac, Mich.
4. Coast Mfg. and Supply Co., Livermore, Calif.
5. Consoweld Corp., Wisconsin Rapids, Wis.
6. Continental Can Co., Inc., 4300 N. Port Washington Rd., Milwaukee, Wis.
7. Continental-Diamond Fibre Co., Newark, Del.
8. Decar Plastic Corp., Middleton, Wis.
9. du Verre, Inc., 108 Park St., Arcade, N.Y.
10. Electro-Technical Products, Div. of Sun Chemical Corp., 113 E. Centre St., Nutley 10, N.J.
11. Fabricon Products, Div. of Eagle-Picher Co., 1721 Pleasant Ave., River Rouge 18, Mich.; 6430 E. Slauson, Los Angeles, Calif.
12. Farley & Loetscher Mfg. Co., Dubuque, Iowa
13. Flexfirm Products, 2300 North Chico Ave., El Monte, Calif.
14. Formica Corp., The, 4614 Spring Grove Ave., Cincinnati 32, Ohio
15. General Electric Co., Coshocton, Ohio
16. Gill Corp., M. C., 1418 Potrero, El Monte, Calif.
17. Glastic Corporation, 4321 Glenridge, Cleveland 21, Ohio
18. Haskelite Mfg. Corp., Grand Rapids 2, Mich.
19. J.P. Lewis Co., Beaver Falls, N.Y.
20. Lunn Industries, Inc., Oakwood Rd. & W. 11th St., Huntington Station, L.I., N.Y.
21. Masonite Corporation, 111 West Washington St., Chicago, Ill.
22. Mica Insulator Co., P.O. Box 1076, Schenectady 1, N.Y.
23. Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.
24. National Vulcanized Fibre Co., Wilmington 99, Del.
25. New England Laminates Co., P.O. Box 43, Stamford, Conn.
26. Northern Plastics Corp., La Crosse, Wis.
27. Panylyte Div., St. Regis Paper Co., Enterprise Ave., Trenton, N.J.
28. Parkwood Laminates, Inc., 24 Water St., Wakefield, Mass.
29. Pioneer Plastics Corp., 28 Goodhue St., Salem, Mass.
30. Richardson Co., The, 2747 Lake St., Melrose Park, Ill.
31. Rogers Corp., Rogers, Conn.
32. Russell Reinforced Plastics Corp., 4 S. 13th St., Lindenhurst, L. I., N.Y.
33. Joseph T. Ryerson & Son, Inc., P.O. Box 8000-A, Chicago 80, Ill.
34. Schori Process Corp., 8-11 43rd Rd., Long Island City 1, N.Y.
35. Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N.Y.
36. Swedlow Inc., 6986 Bandini Blvd., Los Angeles 22, Calif
37. Synthane Corp., Oaks, Pa.
38. Taylor Fibre Co., Norristown, Pa.; La Verne, Calif.
39. Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 30, Pa.
40. Wilmington Fibre Specialty Co., New Castle, Del.
41. Woodall Industries, Inc., 7565 E. McNichols Road, Detroit 34, Mich.
42. Zenith Plastics Co., 1600 West 135th St., Gardena, Calif.
43. Ren Plastics, Inc., 3179 S. Cedar Rd., Lansing 4, Mich.

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* The values for the properties in this chart are based upon maximum and minimum figures submitted by a number of manufacturers of each type of laminate. The manufacturers should always be consulted before making a choice of laminate.

[a] D numbers refer to A.S.T.M. methods.

[b] The values reported for this property depend on the size and shape of the test place and the molding conditions. The maximum permissible service temperatures will vary with the formulation of the material, design of the part, and service conditions such as amount of stressing, humidity, etc. Requirements for resistance to heat should be considered a special problem.

Burning Chart

PLASTIC MATERIAL	EASE OF IGNITION	SELF-EXTINGUISHING	CHARACTER OF FLAME
1. Acetal	Moderate	No	Clean blue flame; no smoke
2. Acrylic	Readily	No	Yellow top, blue around bottom edges; some black smoke; spurts
3. Acrylonitrile-butadiene-styrene polymer blend	Readily	No	Yellow; black smoke
4. Alkyd (mineral filled)	Difficult	Yes	Yellow
5. Allyl ester	Moderate	No	Yellow, blue edges; black smoke
6. Aniline formaldehyde	Readily	Yes	Yellow; large spurts; black smoke
7. Butadiene copolymer rubber	Readily	No	Dark yellow; smoky; clumps of carbon in air
8. Butyl rubber	Readily	No	Yellow; black smoke
9. Casein	Moderate	Yes	Yellow; grey smoke
10. Cellulose acetate	Readily	No	Dark yellow; some sooty black smoke
11. Cellulose acetate butyrate	Readily to moderate	No	Dark yellow with slight blue edges; some black smoke (not sooty)
12. Cellulose acetate propionate	Readily	No	Dark yellow; some black smoke
13. Cellulose nitrate	Very readily	No, burns extremely fast	Yellows; very hot
14. Cellulose propionate	Readily	No	Dark yellow; some black smoke
15. Chlorinated polyether	Difficult	Yes	Sputtering, bottom green, top yellow; dense black smoke; clumps of carbon in the air
16. Cold molded (bituminous)	Very difficult	Yes	Yellow; may give off black smoke
17. Cold molded (phenolic or melamine bond)	Will not burn	-	—
18. Diallyl phthalate	90 sec. (Mil M-14 E)	Yes	Yellow; black smoke
19. Epoxy, phthalic anhydride hardened	Readily	No	Yellow, spurts black smoke
20. Epoxy, amine hardened	Readily	No	Yellow, spurts heavy black smoke
21. Ethyl cellulose	Readily	No	Yellow, blue edges
22. Lignin, laminated paper	Moderate	No	Dark yellow; black smoke; light purple edge on flame
23. Lignocellulose	Moderate to difficult	Yes	Yellow; purplish blue around bottom; spurts
24. Melamine-formaldehyde	Difficult	Yes	Light yellow
25 Neoprene	Readily	Yes, slow	Orange-yellow; black smoke; small green section around bottom
26. Nylon	Moderate	Yes	Blue with yellow top
27. Phenolic, cast	Difficult to moderate	Yes	Yellow; sparks
28. Phenolic - impregnated wood	Moderate	Yes, but continues to burn for a few minutes after removal from flame	Yellow
29. Phenolic, laminated, fabric-base	Moderate	No	Yellow; a little black smoke
30. Phenolic, laminated, paper-base	Moderate	No	Yellow; a little black smoke
31. Phenolic, laminated, asbestos	Difficult	Yes	Yellow
32. Phenolic, molded, filler	Difficult	Yes	Yellow
33. Phenolic, molded, no filler	Very difficult	Yes	Yellow; sparks less than cast
34. Polyester, cast	Readily	No	Yellow, black
35. Polyester, standard unfilled	Moderate	No	Yellow; black smoke, burns steadily
36. Polyester-glass mat laminate	Difficult	No	Yellow; some soot
37. Polyethylene	Readily	No	Bottom blue, top yellow
38. Polyethylene (high-density)	Readily to Moderate	No	Bottom blue, top yellow; white smoke
39. Polyethylene (filled)	Difficult	Yes	Yellow with slight smoke
40. Polypropylene	Readily to Moderate (depending on thickness)	No	Bottom blue; top yellow; some white smoke
41. Polymethylstyrene	Readily	No	Similar to polystyrene
42. Polystyrene	Readily	No	Orange-yellow; black dense smoke; large clumps of carbon in the air
43. Polytetrafluoroethylene	Will not ignite in busen flame	Yes	Yellow, green near base
44. Polytrifluorochloroethylene	Does not ignite	-	—
45. Rubber, hard, natural	Readily	No	Orange-yellow; black smoke; spurts or shoots of light yellow flame
46. Rubber, natural	Readily	No	Dark yellow; black smoke
47. Shellac	Easily	No	Orange-yellow; blue around bottom edges; black smoke; a few blue-light yellow spurts
48. Styrene-acrylonitrile copolymer	Readily	No	Yellow; heavy black smoke
49. Urea-formaldehyde	Difficult	Yes	Pale yellow with light greenish-blue edge
50. Vinyl acetate	Readily	No	Dark yellow flame; spurts, black smoke; clumps of carbon smaller than that from polystyrene
51. Vinyl alcohol compound	Readily	No	Yellow; black smoke
52. Vinyl butyral	Readily	No	Bottom blue, top yellow
53. Vinyl chloride	Difficult	Yes	Yellow, green on bottom edges; spurts green and yellow; white smoke
54. Vinyl chloride-acetate	Difficult to moderate	Yes	Dark yellow; smoky; green at edges
55. Vinylidene chloride	Very difficult	Yes	Yellow, green on edges; spurts green
56. Vulcanized fibre	Moderate	No	Light yellow; purple edges

When using these burning tests, it should be kept in mind that so many modifications of existing plastics materials are being made available that at times the burning characteristics of different formulations within a single group may differ radically. More and more frequently, special

BEHAVIOR OF MATERIAL	ODOR
1. Melts; drips; drippings continue to burn	None while burning; formaldehyde on extinguishing
2. Softens; usually no drip; very little char left after flame is blown out	Characteristic, acrylic monomers (fruity)
3. Softens and chars	Characteristic
4. Chars, cracks	Characteristic, polyesters
5. Cracks and pieces fall off; fallen pieces continue to burn; turns yellow, small amount of melted material at edges of burned area	Characteristic, allyl resins
6. Swells; softens	Characteristic, formaldehyde
7. Softens	Characteristic
8. Softens; cracks	Characteristic (medicinal)
9. Swells; chars	Burning protein materials, e.g. wool, milk curds, silk, etc.
10. Melts; drips; drippings continue to burn	Characteristic (burnt sugar)
11. Melts; drips; drippings continue to burn	Characteristic; butyric acid; (rancid butter)
12. Melts; drips; drippings continue to burn	Characteristic; propionic acid
13. Material burns completely	Burns too fast to detect
14. Melts; drips; drippings continue to burn	Characteristic; propionic acid
15. Softens, no drip	Characteristic
16. Chars	Bituminous; waxy odor
17. –	–
18. Softens	Characteristic
19. Melts at edge; chars	Characteristic
20. Chars	Characteristic
21. Melts; drips; drippings continue to burn	Characteristic; resembles cellulose acetates, except LT composition which resembles burning oil and wax
22. Swells; cracks between laminae; softens	Resembles burning wood
23. Swells, cracks	Resembles burning wood, may be slightly sweet
24. Swells, cracks; turns white at edges of burned section	Characteristic penetrating odor; resembles urea; ammonia and formaldehyde present
25. Softens, char remains	Characteristic, slight resemblance to natural rubber, sharp component present
26. Melts, drips, and froths	Characteristic (burning proteins)
27. Cracks badly and deeply	Phenolic, strong with formaldehyde
28. Swells; cracks	Wood; phenolic
29. Swells; cracks between laminae; cloth continues to glow	Fabric; phenolic
30. Swells; cracks between laminae	Paper; phenolic
31. Surface cracks (blisters) and oxidizes	Phenolic; formaldehyde
32. Swells, cracks; (wood-filled blisters and has afterglow and white ash)	Phenolic; odor from resin may be temporarily marked by odor from decomposing organic fillers such as woodflour, e.g. burnt wood
33. Cracks	Phenolic
34. Melts at edges	Characteristic, polyester
35. No drip or falling particles; softens; burns steadily	Characteristic (slightly bituminous)
36. Chars	Characteristic
37. Melts and drips	Burning paraffin
38. Melts and drips	Burning paraffin
39. Softens, char remains	Burning paraffin
40. Melts and drips	Burning paraffin
41. Softens	Characteristic, methylstyrene monomer
42. Softens, bubbles	Characteristic, styrene monomer
43. Melts, bubbles, slight charring	Very little odor
44. Softens	Characteristic
45. Swells, material does not soften, but liquid comes to surface	Characteristic
46. Softens	Characteristic
47. Softens	Characteristic (sealing wax)
48. Melts; bubbles; chars more than polystyrene	Characteristic, polyacrylonitrile
49. Swells; cracks; turns white at edges of burned section	Characteristic; urea; strong with formaldehyde; (strong pancake odor)
50. Softens	Characteristic; resembles other vinyls except for absence of chlorine; resembles polystyrene
51. Softens; spatters; blisters	Characteristic; resembles vinyl
52. Melts and drips; drippings usually do not continue to burn	Characteristic, resembles vinyl and butyric acid
53. Softens	Characteristic; chlorine
54. Softens; chars; bubbles	Characteristic; hydrochloric acid detectable
55. Softens; chars; leaves ash	Characteristic; chlorine
56. Swells at edges; splits on laminae; smolders	Burning hay or grass

self-extinguishing formulations are also being made available. These tests are most reliable when authentic samples of the actual material are used for comparison with the unknown material.

Fibers Chart

PROPERTIES*	ACETATE *Regular*	TRIACETATE *(Arnel)*†	SAPONIFIED ACETATE *Fortisan*†	SAPONIFIED ACETATE *Fortisan-36*	FIBER K ELASTOMER	CUPRAMMONIUM RAYON
Dimensions of fibers 1. Continuous length	Yes	Yes	Yes	Yes	Yes	Yes
2. Staple length, in.	9/16 to 7	Any std. commercial length	–	–	–	1.5-7
3. Width, microns	11-73	17-40	3-9	3-9	–	5-11
4. Specific gravity at 25°C	1.30-1.35	1.30	1.5	1.52	Approx. 1.0	1.54
Tensile properties at break 5. Tenacity 21°C. and 65% R.H., g./denier	1.1-1.4	1.2-1.4	7.0	8+	0.6-0.8	1.7-2.3
6. Tensile strength at 21°C. and 65% R.H., p.s.i.	18,000-23,000	20,000-23,000	138,000	155,000	–	33,000-42,000
7. Wet, percent of strength at 21°C., 65% R.H.	60-70	67-70	85	75	–	59
8. Ultimate elongation at 65% R.H., percent	25-45	25-40	6	6	520-610	10-17
Recovery from strain[b] 9. Strain, percent	2 | 20	3-10	2 | 5	2 | 5	93.5-96% from 50% elongation	5 | 15
10. Recovery, percent	94 | 23	88-43	75 | 63	82 | 75	–	48 | 32
Modulus of elasticity 11. Static method,[c] 10^{10} dynes/cm.^{2}	3.0-4.8	3.5-5.2	20.4-24.5	34	–	9.2
12. Static method,[c] g./denier	26-41	35-45	152-183	250	–	68
13. Velocity of sound method,[e] 10^{10} dynes/cm.^{2}	6.1	–	–	–	–	–
14. Velocity of sound method,[e] g./denier	52	–	–	–	–	–
15. Stiffness,[f] average, g./denier	5.2	5.3	120	135	–	14
16. Toughness index,[g] g.-cm./denier cm.	0.19[g]	0.18	0.21	0.26	–	0.14
17. Moisture regain at 21° C., 65% R.H., percent	6.3-6.5	3.2	10.0-11.5	9-10	0.3%	14-15
18. Swelling in water,[h] percent	15-30	–	18-26	–	–	99-134
Refractive index 19. Epsilon[i]	1.478	1.472	1.547	1.551	–	1.548
20. Omega[j]	1.473	1.471	1.523	1.520	–	1.527
21. Dielectric constant[v]	3.8 at 60 cy. (0% R.H.) 5.0 at 60 cy. (50% R.H.)	4.1 at 60 cy. (dry) 3.7 at 10^6 cy. (dry)	–	–	–	–
22. Effect of age	Virtually none	Virtually none	Similar to cotton		–	Virtually none
23. Effect of heat, °F.	Becomes sticky 350 to 375	Scorching resistance exceptionally high; 86% of original strength retained after 11 days' exposure at 302	Similar to cotton		Yellows and degrades over 300°F.	Decomposes 300; burns readily
24. Softening temperature, °F.	375-400 Melts at 500	Non-heat-treated softening point as measured in terms of safe ironing temperature 365. Heat-treated 465-482°, melting point 572.	–		Sticks at 347° F. Melts at 482° F.	–
25. Effect of sunlight, prolonged exposure	Loss of tensile strength No discoloration	Highly resistant under glass; unprotected sunlight exposure somewhat less.	Similar to cotton		–	Loss of tensile strength
26. Resistance to moths[k]	Not attacked	Not attacked	Not attacked		–	Not attacked
27. Resistance to mildew[l]	Resistant	Highly resistant; essentially undamaged by 12-wk. soil burial test	Similar to cotton		–	Attacked
28. Effect of strong acids	Decomposed	Degraded	Decomposed		Resistant	Disintegrated by hot dilute or cold concentrated
29. Effect of weak acids	Dissolved by certain weak organic acids, such as acetic	Unaffected by dilute solutions of weak acids	Resistant		Resistant	Similar to viscose
30. Effect of strong alkalies	Saponified	Slowly saponified; only slightly affected at low temperatures (mercerizing conditions)	Swelling and mercerization; loss of strength in hot conc.		Resistant	Swelling and loss of strength
31. Effect of weak alkalies	Little or no effect for short periods; cold. Saponification on long standing or hot.	Little or no effect at 9.5 pH at 200° F. under normal scouring conditions	Little effect		Resistant	Little effect if dilute
32. Effect of organic solvents	Insoluble in dry cleaning solvents generally; swollen or dissolved in acetone, ethyl acetate, many ketones and esters, glacial acetic acid, phenol, and some chlorinated solvents. Softened in alcohol	Unaffected by dry cleaning solvents; swollen by acetone, other ketones and trichloroethylene. Soluble in methylene chloride	Resistant		Not attacked	Resistant
33. Dyes used	Dispersed acetate dyestuffs; selected vats and azo colors; some acid and basic dyes; pigment dyes; solvent (swelling) dyeing	Selected dispersed "acetate" dyestuff; developed azo colors; selected sulfur and vat colors; solvent (swelling) dyeing	Dyes used for cotton; direct colors, sulfurs, naphthols, and vat dyes		Acid, premetallized, disperse, vat, cationic, direct	Same as for viscose rayon

* Footnotes are on page 559.
† Trade mark, see page 559.

	VISCOSE RAYON						NYLON				TFE-FLUOROCARBON^t *(Teflon)*†	VINYL CHLORIDE-VINYL ACETATE *Staple*
	Regular		*Medium tenacity*		*High tenacity*		*Continuous filament*			*Staple*		
							Regular		*High tenacity*			
1.	Yes		Yes		Yes		Yes		Yes	–	Yes	–
2.	1 to 8		1 to 8		No		–		–	1-1/8 to 7-1/2	Various	1 to 5
3.	10-225		8.4-43		10-15		11-71		16-43	14-43	–	16-18
4.	1.50-1.54		1.50-1.54		1.50-1.54		1.14		1.14	1.14	2.3	1.33-1.36
5.	1.5-2.4		2.4-3.0		3.0-5.0		4.5-6.0		6.0-8.8	4.0-4.8	1.6	0.6-0.7
6.	29,000-47,000		47,000-58,000		58,000-97,000		66,000-88,000		88,000-128,000	58,000-70,000	47,000	10,000-12,000
7.	44-54		56-63		55-63		85-90		85-90	85-90	100	100
8.	15-30		10-20		9-20		26		15-23	33-45	13	10-13
9.	2	20	2	20	2	15	2	8^g	4^g	–	–	–
10.	82	30	82	30	82	37	100	100	100	–	–	–
11.	6.4-9.1		12.5		9.9-23.6		3.0		–	1.5	–	$3.3\text{-}4.5^d$
12.	48-68		93		74-176		30		–	15	16	$28\text{-}38^d$
13.	11.5-13		20		20-33.8		6.0		–	–	–	–
14.	86-96		147		150-252		abt. 60		–	–	–	–
15.	8.7		17		25		$14\text{-}24^f$		$26\text{-}58^f$	$9\text{-}15^f$	–	5.8
16.	0.23		0.22		0.25		0.54-0.70		0.59-0.69	0.79-0.90	–	0.04
17.	11.5-16.6		11.5-16.6		11.5-16.6		4.0-4.5				0	0
18.	45-82		45-82		45-82		About 2				0	0
19.	1.547		1.547		1.547		1.547				–	1.536
20.	1.521		1.521		1.521		1.521				–	1.536
21.	–		–		–		4.0 at 1 kc. (18% R.H.) 20.0 at 1 kc. (wet)				–	–
22.	Slight yellowing						None				–	None
23.	Does not melt; decomposes 350-400; burns readily						Yellows slightly on extended exposure to temperatures above 300° F. Sticks at about 455° F.				Decomposes slowly above 525	Melts at 260. Does not burn
24.	–						Nylon 66 melts at 482° F. Nylon 6 melts at 420° F.				–	Softens at 170
25.	Loss of tensile strength						Some loss of strength. No discoloration				–	None
26.	Not attacked						Not attacked				Not attacked	Not attacked
27.	Attacked						Not attacked				Not attacked	Not attacked
28.	Similar to cotton						Disintegrated by conc. mineral acids				Not attacked	Stable
29.	Strength deterioration on prolonged contact or hot						Generally good resistance				Not attacked	Stable
30.	Swelling and loss of strength						Virtually none				Not attacked	Stable
31.	No effect cold; reduced strength hot or on prolonged contact						None				Not attacked	Stable
32.	Resistant						Unaffected by dry cleaning solvents. Soluble in some phenolic compounds and in conc. (90%) formic acid				Not attacked	Soluble in ketones and some chlorinated hydrocarbons; swells and softens in ethers, esters, aromatic hydrocarbons, dioxane, propylene oxide.
33.	Acid (for tinting only); basic; direct; vat; naphthols; sulfur						Disperse and acid are usually preferred, but most other classes are also used				–	Dispersed dyes with aid of certain swelling agents; solvent methods; pigment dyeing.

† Trademark, see page 559.

<table>
<tr><th rowspan="4">PROPERTIES*</th><th colspan="9">POLYESTER</th><th colspan="4" rowspan="2">VINYLIDENE CHLORIDE RESIN
(Saran)</th></tr>
<tr><th colspan="6">DACRON†</th><th colspan="3">KODEL†</th></tr>
<tr><th colspan="4"><i>Filament</i></th><th colspan="2" rowspan="2"><i>Staple</i>^{o}</th><th colspan="3" rowspan="2"><i>Staple</i></th><th rowspan="2"><i>Monofilaments</i></th><th colspan="2" rowspan="2"><i>Continuous multifilaments</i></th><th rowspan="2"><i>Staple</i></th></tr>
<tr><th colspan="2"><i>Regular</i></th><th colspan="2"><i>High tenacity</i></th></tr>
<tr><td>Dimensions of fibers
1. Continuous length</td><td colspan="2">Yes</td><td colspan="2">Yes</td><td colspan="2">–</td><td colspan="3">–</td><td>Yes</td><td colspan="2">Yes</td><td>No</td></tr>
<tr><td>2. Staple length, in.</td><td colspan="2">–</td><td colspan="2">–</td><td colspan="2">1-1/4 to 4-1/2</td><td colspan="3">As desired. Usually 1-1/2 to 3-1/2</td><td>–</td><td colspan="2">–</td><td>1-1/2 up</td></tr>
<tr><td>3. Width, microns</td><td colspan="2">12-23</td><td colspan="2">21</td><td colspan="2">12-25</td><td colspan="3">13-23</td><td>100-1,300</td><td colspan="2">35-100</td><td>35-100</td></tr>
<tr><td>4. Specific gravity at 25° C.</td><td colspan="2">1.38</td><td colspan="2">1.38</td><td colspan="2">1.38</td><td colspan="3">1.22</td><td>1.70 ± 0.05</td><td colspan="2">1.70 ± 0.05</td><td>1.70 ± 0.05</td></tr>
<tr><td>Tensile properties at break
5. Tenacity 21° C. and 65% R.H., g./denier</td><td colspan="2">4.6-5.0</td><td colspan="2">6.0-7.0</td><td colspan="2">3.8-4.4</td><td colspan="3">2.7</td><td>1.1-2.9</td><td colspan="2">Up to 2</td><td>Up to 2</td></tr>
<tr><td>6. Tensile strength at 21° and 65% R.H., p.s.i.</td><td colspan="2">81,000-88,000</td><td colspan="2">106,000-124,000</td><td colspan="2">67,000-78,000</td><td colspan="3">48,000</td><td>25,000-60,000</td><td colspan="2">Up to 44,000</td><td>Up to 44,000</td></tr>
<tr><td>7. Wet, percent of strength at 21° C., 65% R.H.</td><td colspan="2">100</td><td colspan="2">100</td><td colspan="2">100</td><td colspan="3">100</td><td>100</td><td colspan="2">100</td><td>100</td></tr>
<tr><td>8. Ultimate elongation at 65% R.H., percent</td><td colspan="2">19-23</td><td colspan="2">10-13</td><td colspan="2">30-36</td><td colspan="3">27</td><td>20-35</td><td colspan="2">15-25</td><td>15-35</td></tr>
<tr><td>Recovery from strain^{b}
9. Strain, percent</td><td>2</td><td>8</td><td>2</td><td>8</td><td>–</td><td>–</td><td>2</td><td>5</td><td>10</td><td>10</td><td>3</td><td>10</td><td>–</td></tr>
<tr><td>10. Recovery, percent</td><td>97</td><td>80</td><td>100</td><td>90</td><td>–</td><td>–</td><td>94</td><td>55</td><td>35</td><td>95 (5 min.)</td><td>98.5</td><td>93 (5 min.)</td><td>–</td></tr>
<tr><td>Modulus of elasticity
11. Static method,^{c} 10^{10} dynes/cm.^{2}</td><td colspan="2">12.2</td><td colspan="2">14.6</td><td colspan="2">6.1</td><td colspan="3">–</td><td>0.3-1.7</td><td colspan="2">–</td><td>–</td></tr>
<tr><td>12. Static method,^{e} g./denier</td><td colspan="2">100</td><td colspan="2">120</td><td colspan="2">50</td><td colspan="3">30</td><td>2-11</td><td colspan="2">6-10</td><td>6.10</td></tr>
<tr><td>13. Velocity of sound method,^{e} 10^{10} dynes/cm.^{2}</td><td colspan="2">14.6</td><td colspan="2">–</td><td colspan="2">–</td><td colspan="3">–</td><td>–</td><td colspan="2">–</td><td>–</td></tr>
<tr><td>14. Velocity of sound method,^{e} g./denier</td><td colspan="2">Abt. 120</td><td colspan="2">–</td><td colspan="2">–</td><td colspan="3">–</td><td>–</td><td colspan="2">–</td><td>–</td></tr>
<tr><td>15. Stiffness,^{f} average, g./denier</td><td colspan="2">20-26</td><td colspan="2">46-70</td><td colspan="2">9-12</td><td colspan="3">10-12</td><td>10</td><td colspan="2">8-12</td><td>3-8</td></tr>
<tr><td>16. Toughness index,^{g} g.-cm./denier cm.</td><td colspan="2">0.50</td><td colspan="2">0.37</td><td colspan="2">0.80</td><td colspan="3">0.5</td><td>0.165-0.265</td><td colspan="2">0.165-0.265</td><td>0.125</td></tr>
<tr><td>17. Moisture regain at 21° C., 65% R.H., percent</td><td colspan="6">0.4</td><td colspan="3">0.2</td><td colspan="4">0</td></tr>
<tr><td>18. Swelling in water,^{h} percent</td><td colspan="6">Virtually none</td><td colspan="3">Virtually none</td><td colspan="4">0</td></tr>
<tr><td>Refractive index
19. Epsilon^{i}</td><td colspan="6">–</td><td colspan="3">–</td><td colspan="4">1.60-1.63</td></tr>
<tr><td>20. Omega^{j}</td><td colspan="6">–</td><td colspan="3">–</td><td colspan="4">1.60-1.63</td></tr>
<tr><td>21. Dielectric constant</td><td colspan="6">3.8 at 60 cycles (dry)</td><td colspan="3">–</td><td colspan="4">3.0-5.0 at 60 cy., 1 kc., 1 mc.</td></tr>
<tr><td>22. Effect of age</td><td colspan="6">None</td><td colspan="3">None</td><td colspan="4">Slight</td></tr>
<tr><td>23. Effect of heat, °F.</td><td colspan="6">Resistant to degradation by heat
Melts at 480° F.</td><td colspan="3">Highly resistant. 0.5 g./denier at 500° F.</td><td colspan="4">Strength loss occurs at 160-200</td></tr>
<tr><td>24. Softening Temperature, °F.</td><td colspan="6">Sticks at 455° F.</td><td colspan="3">Safely ironed at 425° F.</td><td colspan="4">Shrinks at 160-250 if not under restraint; softens at 240-280</td></tr>
<tr><td>25. Effect of sunlight, prolonged exposure</td><td colspan="6">Some loss of strength. No discoloration. Much more resistant behind glass than in direct sunlight</td><td colspan="3">No discoloration, slight loss of strength. More resistant behind glass.</td><td colspan="4">Darkens slightly</td></tr>
<tr><td>26. Resistance to moths^{k}</td><td colspan="6">Not attacked</td><td colspan="3">Not attacked</td><td colspan="4">Not attacked</td></tr>
<tr><td>27. Resistance to mildew^{l}</td><td colspan="6">Not attacked</td><td colspan="3">Not attacked</td><td colspan="4">Not attacked</td></tr>
<tr><td>28. Effect of strong acids</td><td colspan="6">Very resistant to most mineral acids. Disintegrated by 96% sulfuric</td><td colspan="3">Very resistant</td><td colspan="4">Stable</td></tr>
<tr><td>29. Effect of weak acids</td><td colspan="6">Virtually none</td><td colspan="3">Virtually none</td><td colspan="4">Stable</td></tr>
<tr><td>30. Effect of strong alkalies</td><td colspan="6">Resistant when cold. Degraded at boil</td><td colspan="3">Very resistant</td><td colspan="4">Stable to most; limited resistance to ammonia</td></tr>
<tr><td>31. Effect of weak alkalies</td><td colspan="6">Good resistance</td><td colspan="3">Virtually none</td><td colspan="4">Stable</td></tr>
<tr><td>32. Effect of organic solvents</td><td colspan="6">Generally unaffected.
Soluble in some hot phenolic compounds</td><td colspan="3">Generally insoluble</td><td colspan="4">Swelled or softened by oxygen-bearing solvents (cyclohexanone, dioxane) at elevated temperatures. Not affected by alcohols or aliphatic hydrocarbons. Aromatic hydrocarbons, halogenated hydrocarbons, ketones, esters, and ethers may be detrimental in varying degrees.</td></tr>
<tr><td>33. Dyes used</td><td colspan="6">Disperse, azoic, and vat with carrier or at high temperatures</td><td colspan="3">Disperse, with carrier, and azoic</td><td>Colored before extrusion</td><td colspan="2">Colored before extrusion. Selected acetate type dyestuffs</td><td>Colored before extrusion. Selected acetate type dyestuffs</td></tr>
</table>

* Footnotes are on page 559.
† Trade mark, see page 559.

	ACRYLICS						POLYETHYLENE *Monofilaments*		POLY-PROPYLENE
	Dynel†	**Orlon†**	**Acrilon†**	**Creslon†**	**Acrylast†**	**Verel†**	*Low-density*	*High-density*	*Monofilaments*
	Staple	*Staple*	*Staple*	*Staple*	*Filament*	*Staple*			*Isotactic*
1.	–	–	–	No	Yes	–	Yes	Yes	Yes
2.	1-1/4 to 5 or tow	1-1/4 to 4-1/2	½" to 6" tow	1.25 to 4.0 and tow	–	1.0 to 6	–	–	–
3.	Ratio of width to thickness 5-6: 1	$11\text{-}36^{p}$	15-43	16.5-21.5	200-500	–	200-500	100-500	100-500
4.	1.30	1.14	1.17	1.17	1.09-1.10	1.37	0.92	0.94-0.96	0.90-0.91
5.	3.0^{b}	2.3-2.6	2.0-2.7	3.4^{w}	1.4-2.5	2.5-2.8	1.0-2.7	4.2-8.0	5.0-7.0
6.	50,000	33,000-38,000	30,000-40,000	$67{,}000^{w}$	20,000-35,000	42,000-47,000	11,000-33,000	50,000-96,000	60,000-85,000
7.	100	–	80	–	100	95	100	100	100
8.	39	20-28	36-40%	36^{w}	40-50	33-35	20-100 (oriented)	10-30	15-25
9.	2^{w} 5^{w} 10^{w}	–	2 5	1 3 5^{x}	2 8	4 10	5^{d}	5 10	5 15
10.	100 98 95	–	99 89	81.5 61 45^{x}	100 35	88 55	95	95 80	98 95
11.	2.6^{w}	5.0	–	–	–	–	–	–	–
12.	23^{w}	50	44	48^{w}	Ca 30	40.0	–	20-40	35-45
13.	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–
15.	7.7^{w}	11	7.0	9.4^{w}	Ca. 30^{u}	8.0	2-12	$20\text{-}40^{u}$	35-45
16.	0.58^{w}	0.31^{g}	0.46	0.61^{w}	0.4-0.5	0.46	0.3	0.4-0.8	–
17.	0.4	1.5	1.5	1.5	0.5 max.	3.5-4	0	0	0
18.	Very slight	Slight	Slight	Very slight	0	Virtually none	0	0	0
19.	–	–	1.522	1.517	–	1.538	–	–	–
20.	–	–	–	1.521	–	–	–	–	–
21.	–	4.8 at 60 cycles	3.1 at 10^3 cycles 2.8 at 10^6 cycles	–	3.4 at 60 cycles 3.1 at 10^6 cycles	4.0 at 60 cycles; greater than 1500 volts/mil	–	2.3 at 1 kc. and 1 mc.	2.0-2.1
22.	Virtually none	None	None	Virtually none	None	Virtually none	Virtually none at room temperature		Virtually none at room temperature
23.	Begins to shrink at 250° F. unless stabilized at higher temp.	Resistant to degradation by heat	Shrinks 5% at 487 10% at 511	–	Shrinks at 180	Very difficult to ignite. Self-extinguishing. Strength and elongation unaffected after 100 hours at 230° F.	5% shrinkage at 165	1-4% shrink at 160; 5-10% shrink at 212	4-8% shrinkage at 165° F., 10-15% at 210° F.
24.	Strain release occurs above 240 unless fiber is stabilized	Sticks at 455-480	Sticks at 475	425^{y}	240-280	Exposure over 300 causes stiffening and discoloration.	Melts at 230-250	Softens at 240-250 Melts at 250-270	Melts at 330°-348° F. Softens at 300°-310° F.
25.	Very resistant	Very high resistance to sunlight deterioration	Highly resistant	Negligible	Slight yellowing, No loss of strength.	Excellent resistance	Some loss of tensile for clear; much less for pigmented. No darkening		Some loss of tensile strength for clear; less for pigmented, no darkening.
26.	Not attacked	Not attacked	Not attacked	Not attacked	Not attacked	Not attacked	Not attacked		Not attacked
27.	Not attacked	Not attacked	Not attacked	Not attacked	Not attacked	Not attacked	Not attacked		Not attacked
28.	Very resistant except to: 25% chromic 70% nitric 96% sulfuric	Very resistant to most mineral acids. Disintegrated by 96% sulfuric	Moderate resistance	Good resistance to strong organic acids. Loses strength to high concentration of strong inorganic acids.	Fair resistance to HCl and H_2SO_4 Poor resistance to HNO_3.	Excellent resistance at high concentration	Very resistant		Very resistant
29.	Little or no effect	Virtually none	Little or no effect	No loss in strength	Virtually none	No effect	Very resistant		Very resistant
30.	Very resistant	Resistant when cold. Degraded at boil	Resistant	Some loss of strength and yellowing	Good resistance	No loss of tenacity; some discoloration.	Very resistant		Very resistant
31.	Not attacked	Good resistance	Good resistance	Slight yellowing	None	No effect	Very resistant		Very resistant
32.	Unaffected by dry-cleaning solvents and most common solvents. Dissolved by warm acetone; partially dissolved by higher ketones, aniline, and ethylene dichloride	Unaffected by common solvents	Insoluble in benzene acetone, petroleum ether, ethyl alcohol dichloroethane, carbon tetrachloride, solvent naphtha, dioxane and others	Unaffected by common solvents	Not resistant to acetone, methyl ethyl ketone, orthodichlorobenzene, dioxane, pyridene, carbon disulfide. Resistant to motor oils, some gasolines and kerosenes, normal heptane, food oils, higher alcohols.	Not affected by dry-cleaning solvents or most organic chemicals other than acrylic-type solvents. Dissolves in warm acetone.	Soluble above 160° F. in some solvents		Soluble above 160° F. in some solvents
33.	Disperse, acid, direct, premetallized, cationic, and some vat dyes.	Cationic, disperse, acid (copper technique), and selected vat and naphthol.	Acid, chrome, premetallized, acetate, basic, and vat. Ordinary dyeing procedures used.	Acid, metallized neutral metallized, chrome, disperse, acetates, selected directs, and basics.	Pigmented before extrusion	Neutral dyeing premetallized, dispersed (acetate) and basic or cationic.	Pigmented before extrusion		Pigmented before extrusion

† Trade mark, see page 559.

PROPERTIES*	COTTON	SILK	WOOL	GLASS	ASBESTOS
Dimensions of fibers					
1. Continuous length	No	400 to 1300 yards	No	Yes	No
2. Staple length, in.	1/2 to 2-1/2	Yes	1-1/2 to 15	Up to 18	Up to 3/4
3. Width, microns	12-20	9-11	10-70	5-10	–
4. Specific gravity at 25 °C.	1.50-1.55	1.25-1.35	1.28-1.33	2.54	2.5
Tensile properties at break					
5. Tenacity 21 °C. and 65% R. H., g./denier	2.1-6.3	2.8-5.2	1.0-1.7	7.7	–
6. Tensile strength at 21 °C. and 65% R. H., p.s.i.	42,000-125,000	45,000-83,000	17,000-28,000	250,000-315,000	200,000-400,000
7. Wet, percent of strength at 21 °C., 65% R.H.	110-130	75-95	76-97	99	90-100
8. Ultimate elongation at 65% R.H., percent	3-10	13-31	20-50	2.5-3.15	–
Recovery from strain^b					
9. Strain, percent	2 5	2 20	2 20	3^d	–
10. Recovery, percent	74 45	92 33	99 63	100	–
Modulus of elasticity					
11. Static method,^{c} 10^{10} dynes/cm.^{2}	5.7-11.2	8.4-12.9	2.7-3.9	68.9	–
12. Static method,^{c} g./denier	42-82	76-117	24-34	307	–
13. Velocity of sound method,^{e} 10^{10} dynes/cm.^{2}	–	14.4	5.1	74	–
14. Velocity of sound method,^{e} g./denier	–	130	44	331	–
15. Stiffness,^{f} average, g./denier	60	18	3.9	300	–
16. Toughness index,^{g} g.-cm./denier cm.	0.15	0.44	0.25	0.13	–
17. Moisture regain at 21 °C., 65% R. H., percent	8.5	11.0	17.0	0	–
18. Swelling in water,^{h} percent	44-49	30-41	32-38	0	–
Refractive index					
19. Epsilon^i	1.580	1.591	1.556	1.55 ± 0.01	–
20. Omega^j	1.533	1.538	1.547	1.55 ± 0.01	–
21. Dielectric constant	–	4.2 at 500 kc., 4 mc., 10 mc.	4.2 at 13 mc. 500 kc., 120 kc. 4.8 at 20 kc. 5.4 at 8 kc.	6.3 at 60 cy. 6.3 at 1 mc. 5.8 at 10 mc. 5.6 at 37 mc.	–
22. Effect of age	Virtually none	Slight yellowing; slight loss of tensile	Slight yellowing; slight loss of tensile	None	None
23. Effect of heat, °F.	Yellows at 248 Decomposes at 302 (5 hrs.)	1% shrinkage at 350	Decomposes 266 Scorches 400 Chars 572	No loss at 475 50 % loss at 685	Very little up to 900
24. Softening temperature, °F.	–	–	–	1380-1550	Melts at 2770
25. Effect of sunlight, prolonged exposure	Loss of tensile; tendency for whites to yellow	Loss of tensile strength	Loss of tensile. Dyeing affected	None	None
26. Resistance to moths^k	Not attacked	May be attacked but less than wool	Attacked	Not attacked	Not attacked
27. Resistance to mildew^l	Attacked, especially if sized	Not usually attacked	May be attacked but more resist. than cotton	Not attacked	Not attacked
28. Effect of strong acids	Disintegrated by hot dilute or cold conc.	Dissolved	Destroyed by hot sulfuric; resistant to others	Attacked by hydrofluoric and hot phosphoric	Affected
29. Effect of weak acids	Stable if cold; strength deterioration if hot	Moderately resistant	Resistant	Stable	Resistant
30. Effect of strong alkalies	Swelling and mercerization	Dissolved	Attacked	Attacked	Resistant
31. Effect of weak alkalies	Little effect	Attacked if hot	Attacked if hot	Attacked if hot	Resistant
32. Effect of organic solvents	Resistant	Resistant	Resistant	Insoluble	Insoluble
33. Dyes used	Basic, direct, mordant, sulfur, vat, naphthols	Acid, basic, direct, mordant, naphthols, vat	Acid, basic, direct, mordant, vat	Resin-bonded pigments; also other dyes used on coated fibers	–

*Footnotes are on page 559.

Synthetic Fibers[a]: Manufacturers and Trade Names

Acetate

Avisco. American Viscose, 1617 Pennsylvania Blvd., Philadelphia 3, Pa.

Celanese, Celaperm, Celacloud, Celafil, Celaire, Type F and *Type K.* Celanese Corp. of America, 180 Madison Ave., New York 16, N.Y.

Du Pont acetate. E.I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

Teca, Estron, Chromspun. Estron and Chromspun acetate fiber, Eastman Chemical Products, Inc., Kingsport, Tenn.

Triacetate

Arnel. Celanese Corp. of America, 180 Madison Ave., New York 16, N.Y.

Rayon, Saponified Acetate

Fortisan, Fortisan-36. Celanese Corp. of America, 180 Madison Ave., New York 16, N.Y.

Rayon, Cuprammonium

Bemberg, Matesa. American Bemberg, 261 Fifth Ave., New York 16, N.Y.

Rayon, Viscose

Avisco. American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.

Briglo, Englo, Enka, Jetspun, Perlglo, Skyloft, Suprenka, Tempra. American Enka Corp., 530 Fifth Ave., New York 16, N.Y.

Celanese Corp. of America, 180 Madison Ave., New York 16, N.Y.

Cordura, Super Cordura. Du Pont rayon. E.I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

Covingtone, Suede-Skin, Spun-Black, Superwind, Dul-Tone, Spun-Lo, Tyron, Nupron, Premier, Covinair, Lektroset. Industrial Rayon Corp., Union Commerce Bldg., Cleveland 1, Ohio

Narco, Hi-Narco, Super-Narco, Semi-Dul, Xtra-Dul. North American Rayon Corp., 261 Fifth Ave., New York 16, N.Y.

Newbray, Newdull, Newlow. New Bedford Rayon Div., Mohasco Industries, Inc., Box 908, New Bedford, Mass.

Veri-Dul. Skenandoa Rayon Corp., 261 Fifth Ave., New York 16, N.Y.

Nylon

Chemstrand nylon. Chemstrand Corp., 350 Fifth Ave., New York 1, N.Y.

Du Pont nylon. E.I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

Enka nylon. American Enka Corp., 206 Madison Ave., New York 16, N.Y.

Firestone nylon monofilament. Firestone Plastics Co., Div. of Firestone Tire & Rubber Co., Box 690, Pottstown, Pa.

Industrial Rayon Corp. nylon. Industrial Rayon Corp., 500 Fifth Ave., New York 36, N.Y.

Polyester

Dacron. E.I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

Kodel. Eastman Chemical Products, Inc., Kingsport, Tenn.

TFE-fluorocarbon

Teflon. E.I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

Vinyl Chloride-Vinyl Acetate Resin

Vinyon HH. American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.

Vinylidene Chloride Resin

Bolta saran. Bolta Products, Div. of The General Tire & Rubber Co., Lawrence, Mass.

Dawbarn saran. Dawbarn Brothers, Inc., Waynesboro, Va.

Lus-Trus saran. Southern Lus-Trus Corp., 1048 Escambia St., Jacksonville, Fla.

National saran. National Plastics Products Co., Odenton, Md.

Velon. Firestone Plastics Co., Div. of Firestone Tire & Rubber Co., Box 690, Pottstown, Pa.

Saran. The Saran Yarns Co., Odenton, Md.

Elastomer

Fiber K. E.I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

Acrylic

Acrilan. Chemstrand Corp., 350 Fifth Ave., New York 1, N.Y.

Boltathene. Bolta Products, Div. General Tire & Rubber Co., Lawrence, Mass.

Creslan. American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N.Y.

Dynel. Union Carbide Chemicals Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17, N.Y.

Orlon. E.I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

Verel. Eastman Chemical Products, Inc., 260 Madison Ave., New York 16, N.Y.

Polyethylene

Boltathene. Bolta Products, Div. The General Tire & Rubber Co., Lawrence, Mass.

DLP. Dawbarn Brothers, Inc., Waynesboro, Va.

Firestone. Firestone Plastics Co., Div. of Firestone Tire & Rubber Co., Box 690, Pottstown, Pa.

Reevon. Reeves Brothers, Inc., 1071 Ave. of the Americas, New York 18, N.Y.

Wynene. National Plastics Products Co., Odenton, Md.

Polypropylene

DLP. Dawbarn Brothers, Inc., Waynesboro, Va.

Firestone. Firestone Plastics Co., Div. of Firestone Tire & Rubber Co., Box 690, Pottstown, Pa.

Reevon. Reeves Brothers, Inc., 1071 Ave. of the Americas, New York 18, N.Y.

Glass

Fiberglas. Owens-Corning Fiberglas Corp., Textiles Div., 16 E. 56th St., New York 22, N.Y.

Garan, Vitron. Johns-Manville, 22 E. 40th St., New York 16, N.Y.

Modiglass. Modigliani Glass Fibers, Inc., 70 Pine St., New York 5, N.Y.

Pittsburgh PPG. Pittsburgh Plate Glass Co., Fiber Glass Div., One Gateway Center, Pittsburgh 22, Pa.

Unifab, Uniformat, Unirove. Ferro Corporation, Fiber Glass Div., Fiber Glass Rd., Nashville 11, Tenn.

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[a] This compilation of the principal physical and chemical properties of the commercially important textile fibers was originally prepared for the Modern Plastics Encyclopedia by Harris Research Laboratories.

[b] Except as otherwise noted, all values for elastic recovery were obtained at 20° C. and 65% relative humidity; rate of loading 10 g./denier/min.; duration of action of load 30 sec.; recovery time 60 sec.

[c] Except as otherwise noted, all values of static method were obtained under the same conditions described in footnote (b).

[d] Testing conditions not reported.

[e] All values by the velocity of sound method were obtained in air-dry condition.

[f] Stiffness (resistance to deformation) is the ratio of breaking stress to breaking strain, P/E, where P is the stress in grams per denier required to produce rupture and E is the strain in centimeters per gage centimeter at breaking stress.

[g] Toughness (the ability to absorb work), expressed as a toughness index, is the work per unit (denier and length) or weight of material which would cause rupture if the stress-strain curve were a straight line: PE/2.

[h] Values pertain to cross-section area increase, essentially equivalent to volumetric swelling.

[i] Index for light vibrating parallel to the long fiber axis.

[j] Index for light vibrating perpendicular to the long fiber axis.

[k] Many materials are subject to attack by moths if they contain edible finishes.

[l] Resistance of yarns and fabrics to mildew depends in many cases upon the nature of the finishing materials used.

[m] Rate of loading 1 g./denier/min.

[n] Stretched: rate of loading 7.5 g./denier/min.; duration of action of load 40 sec.; recovery time 60 sec.; stabilized: rate of loading 4 g./denier/min.; duration of action of load 45 sec.; recovery time 60 sec.

[o] Measurements made on uncrimped tow.

[p] Based on circular cross-sections. "Orlon" has "dog-bone" cross-section.

[q] Recovery against no load, samples loaded and load released immediately, recovery within 60 sec. (75° F., 65% R.H.).

[r] "Instron" tester, 10% per min. rate of elongation (75° F., 72% R.H.).

[s] n_D/20° C. = 1.530 obtained on pressed disk of "Vinyon" N resin. Bi-refringence could not be detected in this manner.

[t] Fiber in experimental production only.

[u] Stiffness determined at yield point.

[v] Determined on film

[w] "Instron" tester, 73° F. and 50% R.H. elongation rate 100% of gage length of fiber per minute.

[x] "Instron" tester, 73° F. and 50% R.H. elongation rate 1%, duration of action of load 30 sec.; immediate recovery.

[y] Parr melting block technique.

[z] "Instron" tester, 70° F. and 65% R.H., 100% of gage length of fiber per min. Recovery measured instantaneously upon recovery of zero loading.

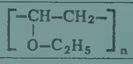
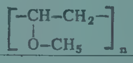
[aa] "Instron" tester, 70° F. and 65% R.H., 100% of gage length of fiber per min.

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25°C.	R. I. AT 25°C.	F. P.	V. P.
						°C.	*mm.Hg*
Abietic acid derivatives							
1. Hydroabietyl alcohol	$C_{19}H_{31}CH_2OH$	$C_{20}H_{34}O$	290	1.008	1.526^c	185	1.5×10^{-5} @25°
2. Methyl abietate	$C_{19}H_{29}COOCH_3$	$C_{21}H_{32}O_2$	316	1.033	1.529^c	180	<0.1@25°
3. Hydrogenated methyl abietate	$C_{19}H_{31}COOCH_3$	$C_{21}H_{34}O_2$	318	1.026	1.519^c	180	<0.1@25°
Adipic acid derivatives							
4. Diethyl adipate	$C_2H_5OCO(CH_2)_4COOC_2H_5$	$C_{10}H_{18}O_4$	202	1.002	1.426	–	–
5. Dibutyl adipate	$C_4H_9OCO(CH_2)_4COOC_4H_9$	$C_{14}H_{26}O_4$	258	0.961	1.434	116	–
6. Di-isobutyl adipate	$[CH_2CH_2COOCH_2CH(CH_3)_2]_2$	$C_{14}H_{26}O_4$	258	0.950^c	1.4293	160	–
7. Di-*n*-hexyl adipate	$C_6H_{13}OCO(CH_2)_4COOC_6H_{13}$	$C_{18}H_{34}O_4$	314	$0.925\text{-}0938^c$	1.4125^c	–	–
8. Dicapryl adipate	$C_8H_{17}OCO(CH_2)_4COOC_8H_{17}$	$C_{22}H_{42}O_4$	371	0.9135^c	–	–	–
9. Di-(2-ethylhexyl) adipate	$C_4H_8[COOCH_2CH(C_2H_5)C_4H_9]_2$	$C_{22}H_{42}O_4$	371	0.9268^c	1.447^c	196	2.4@200°C.
10. Di-isooctyl adipate	$C_8H_{17}OCO(CH_2)_4COOC_8H_{17}$	$C_{22}H_{42}O_4$	371	0.928^c 0.924^c	1.448 1.445	210 195	<0.12@150°
11. Dinonyl adipate	$(CH_2)_4(COOC_9H_{19})_2$	$C_{24}H_{46}O_4$	399	0.9168^c	–	232	–
12. Octyl decyl adipate (n-Octyl,n-decyl adipate) (Iso-octyl isodecyl adipate)	$C_8H_{17}OCO(CH_2)_4COOC_{10}H_{21}$	$C_{24}H_{46}O_4$	399	0.914-0.924	1.446- 1.4505	200-235	<0.04@150°
13. Di-decyl adipate (Di-isodecyl adipate)	$C_{10}H_{21}OCO(CH_2)_4COOC_{10}H_{21}$	$C_{26}H_{50}O_4$	427	0.915- 0.9181^c	1.4498- 1.4512^c	218-227	–
14. Polypropylene adipate modified	–	–	–	1.05^c	1.452^c	–	–
15. Polypropylene adipate	–	–	–	1.14	1.446	–	–
16. Dimethoxyethyl adipate	$CH_3OC_2H_4OCO(CH_2)_4COOC_2H_4OCH_3$	$C_{12}H_{22}O_6$	262	1.075	1.439	–	–
17. Diethoxyethyl adipate	$C_2H_5OC_2H_4OCO(CH_2)_4COOC_2H_4OC_2H_5$	$C_{14}H_{26}O_6$	290	1.036	1.439	–	–
18. Dibutoxyethyl adipate	$(C_4H_9OC_2H_4OCOCH_2CH_2)_2$	$C_{18}H_{34}O_6$	346	0.997^c	1.442	188	<0.17@150°
19. Dihexoxyethyl adipate	$(CH_2)_4(COOC_2H_4OC_6H_{13})_2$	$C_{22}H_{42}O_6$	402	0.9642	1.4440	–	–
20. Dibutoxyethoxy ethyl adipate	$[C_4H_9OC_2H_4OC_2H_4COO(CH_2)_2]_2$	$C_{22}H_{42}O_8$	435	1.025	1.447	166	–
21. Di(methylcyclohexyl) adipate	$CH_3C_6H_{10}OCO(CH_2)_4COOC_6H_{10}CH_3$	$C_{20}H_{34}O_4$	338	1.007	1.468	190	1.95@200°C.
22. Dibenzyl adipate	$C_6H_5CH_2OCO(CH_2)_4COOCH_2C_6H_5$	$C_{20}H_{22}O_4$	326	–	–	–	–
23. Ditetrahydrofurfuryl adipate	$(C_4H_7O.CH_2OCOCH_2CH_2)_2$	$C_{16}H_{26}O_6$	314	–	–	–	–
Azelaic acid derivatives							
24. Di-2-ethylbutyl azelate	$C_6H_{13}OCOC_7H_{14}COOC_6H_{13}$	$C_{21}H_{40}O_4$	356	0.934^c	1.4445	185	–
25. Di-2-ethylhexyl azelate	$C_8H_{17}OCOC_7H_{14}COOC_8H_{17}$	$C_{25}H_{48}O_4$	413	0.9184^c	1.4464	212	–
26. Di-isooctyl azelate	$C_8H_{17}OCOC_7H_{14}COOC_8H_{17}$	$C_{25}H_{48}O_4$	413	0.918- 0.920^c	1.448- 1.450	213-219	–
27. Di-2-ethylhexyl-4-thioazelate	$S(CH_2CH_2CH_2COOC_8H_{17})_2$	$C_{24}H_{46}O_4S$	430	0.955	1.467	–	–
Benzoic acid derivatives							
28. 2-ethylhexyl-p-oxybenzoate	$HOC_6H_4COOC_8H_{17}$	$C_{15}H_{22}O_3$	250	1.04	1.519	–	–
29. Diethylene glycol dibenzoate	$C_6H_5CO(OCH_2CH_2)_2OCOC_6H_5$	$C_{18}H_{18}O_5$	314	1.178 1.1765^c	1.5424 1.5449^c	–	<0.01
30. Dipropylene glycol dibenzoate	$C_6H_5CO(OC_3H_6)_2OCOC_6H_5$	$C_{20}H_{22}O_5$	342	1.129 1.1260^c	1.5282 1.5300^c	–	1.2@200°
31. Triethylene glycol dibenzoate	$C_6H_5CO(OCH_2CH_2)_3OCOC_6H_5$	$C_{20}H_{22}O_6$	358	1.168	–	–	–
32. Polyethylene glycol (200) dibenzoate	$C_6H_5CO(OCH_2CH_2)_xOCOC_6H_5$	–	408	1.158	1.5252	–	–
33. Polyethylene glycol (300) dibenzoate	$C_6H_5CO(OCH_2CH_2)_xOCOC_6H_5$	–	508	1.150	1.5137	–	–
34. Polyethylene glycol (400) dibenzoate	$C_6H_5CO(OCH_2CH_2)_xOCOC_6H_5$	–	608	1.145	1.5077	–	–
35. Polyethylene glycol (600) dibenzoate	$C_6H_5CO(OCH_2CH_2)_xOCOC_6H_5$	–	808	1.141	1.4984	–	–
36. **Benzophenone**	$C_6H_5COC_6H_5$	$C_{13}H_{10}O$	182	1.0976@50°	1.5975@45°	–	–
Biphenyl derivatives							
37. 2-Nitrobiphenyl	$C_6H_5C_6H_4NO_2$	$C_{12}H_9O_2N$	199	1.203	1.612	143	–

*Code for column headings: Sp. Gr. = specific gravity; R. I. = refractive index; F. P. = flash point (Cleveland and Open Cup); V. P. = vapor pressure; B. R. = boiling range; M. P. = melting point; S. in water = solubility in water; CA = cellulose acetate; CAB = cellulose acetate butyrate; CN = cellulose nitrate; EC = ethyl cellulose; PM = polymethyl methacrylate; PS = polystyrene; VA = polyvinyl acetate; VB = polyvinyl butyral; VC = vinyl chloride; and VCA = vinyl chloride acetate.

	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS[a]										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS	MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA		
	°C.	°C.	% by wt.												
1.	–	32-33	Ins.	I	I	C	C	P	I	I	P	C	P	Abitol (41)	41
2.	310 @ 760 mm.[e]	–	Ins.	I	P	C	C	C	C	I	C	C	C	Abalyn (41)	41
3.	350 @ 760 mm.[e]	–	Ins.	I	P	C	C	C	C	I	C	C	C	Hercolyn (41)	41
4.	245	–14	0.060	C	C	C	–	–	–	–	–	–	–		11, 24
5.	168-170 @ 17 mm.	–	Ins.	P	C	C	C	–	–	C	C	C	C	"Kesscoflex" DBA (48)	38, 40, 48
6.	135-147 @ 4 mm.	–20	Ins.	–	C	C	–	–	–	C	–	C	C	"Adipol" DIBA (18) "Darex" DIBA (22) "Kesscoflex" DIBA (48) "Staflex" DIBA (21)	18, 21, 22 38, 40, 48
7.	204-206 @ 8 mm.	–8	0.025[c]	P	C	C	C	C	C	P	P	C	C	"Kesscoflex" DHA (48)	48
8.	213-217 @ 4 mm.	–15	Ins.	C	C	C	C	C	C	P	P	C	C	"Harflex" 280 (38)	38, 40
9.	214 @ 5mm.	<–60[f]	<0.01	P	C	C	C	P	C	P	P	C	C	"Adipol" 2EH (18) DOA 776 (62) "Elastex" 60-A (2) "Flexol" A-26 (72) "Good-rite" GP-233 (35) "Griffin" DOA (34) "Harflex" 250 (38) "Kesscoflex" DOA (48) "Kolflex" DOA (49) "Morflex" 310 (52) "Plastomoll" DOA (10) "Polycizer" 332 (39) "PX"-238 (61) "RC" DOA (64) "Staflex" DOA (21) "Witcizer" 413 (74)	2, 10, 18, 21, 28, 35, 36, 38, 39, 40, 48, 49, 50, 52, 53, 61, 62, 64, 72, 74
10.	205-220 @ 4 mm.	<–70	Ins.	P	C	C	C	C	C	C	P	C	C	"Adipol" 10A (18) "Darex" D10A (22) "Good-rite" GP-233 (35) "Griffin" D10A (36) "Harflex" 220 (38) "Kesscoflex" D10A (48) "Morflex" 300 (52) "PX"-208 (61) "RC" D10A (64) "Staflex" D10A (21) "Witcizer" 412 (74)	2, 18, 21, 22, 35, 36, 38, 40, 48, 49, 52, 53, 61, 64, 74
11.	–	–65	Ins.	P	C	–	C	C	C	–	–	C	C	"Morflex" 390 (52) "Plastomoll" NA (10) "PX"-209 (61)	10, 38, 40, 52, 61
12.	210-232 @ 4 mm.	<–60	<0.01	P	C	C	C	P	C	C	P	C	C	"Adipol" ODY (18) "Adipol" 810 (18) "Elastex" 82-A (2) "Good-rite" GP-235 (35) "Hercoflex" 290 (41) "Kesscoflex" ODA (48) "Morflex" 375 (52) NODA 775 (62) "Polycizer" 532 (39) "PX"-212 (61) "RC" NODA (64) "Staflex" ODA (21)	2, 18, 21, 35, 38, 39, 40, 41, 48, 49, 52, 61, 62, 64
13.	238-246 @ 4 mm. 245 @ 5 mm.	–64[f]	Ins.	P	C	C	C	P	C	C	I	C	C	"Adipol" XX (18) "Darex" DIDA (22) DDA 777 (62) "Elastex" 20-A (2) "Flexol" 10-A (72) "Good-rite" GP-236 (35) "Hexaplas" LMV (44) "Kesscoflex" IDA (48) "Kolflex" DDA (49) "Morflex" 330 (52) "Plasticizer GC-100A"(36) "Polycizer" 632 (39) "PX"-220 (61) "RC" DIDA (64) "Staflex" DDA (21)	2, 18, 21, 22, 35, 36, 38, 39, 40, 44, 48, 49, 50, 52, 61, 62, 64, 72
14.	–	<–20	Ins.	–	–	–	–	–	–	–	–	C	C	"Hexaplas" LMV (44)	14, 44
15.	–	–	Ins.	–	–	–	–	–	–	–	–			"Hexaplas" PPA (44)	44
16.	185-190 @ 11 mm.	–16	1.420	C	C	C	–	–	–	–	–	–	–	"Kesscoflex" MCA (48)	24, 48
17.	165 @ 4 mm.	<–70	0.248	C	C	C	–	–	–	–	–	–	–	–	24
18.	208-215 @ 4 mm.	–34	0.08	P	C	C	C	C	C	P	C	C	C	"Adipol" BCA (18) DBEA 779 (62) "Kesscoflex" BCA (48) "Plastoflex" 3 (1) "Staflex" DBEA (21)	1, 18, 21, 40, 48, 62
19.	–	–6	–	–	–	–	–	–	–	–	–	–	–	–	21
20.	240-260 @ 1-3 mm.	–	0.3	I	I	C	C	–	–	C	C	–	–	TP-95 (70)	70
21.	190-200 @ 3 mm.	–	Ins.	C	C	C	C	P	C	C	C	C	C	"Sextol" adipate (43)	43
22.	–	–	Ins.	–	–	–	–	–	C	–	–	C	C	"Morflex" 350 (52)	38, 52
23.	200-207 @ 1.5 mm.	5-15	Ins.	–	C	–	–	–	–	–	–	–	–	–	24
24.	230 @ 5 mm.	–65	Ins.	C	C	C	C	–	–	P	I	C	C	"Plastolein" 9050 DHZ (29)	29
25.	237 @ 5 mm.	–65	Ins.	C	C	C	C	–	–	P	I	C	C	"Kesscoflex" DOZ (48) "Morflex" 410 (52) "Plastolein" 9058 (29) "Staflex" DOZ (21)	21,28,29,48, 52, 61
26.	225-244 @ 4 mm.	–65	Ins.	C	C	C	C	–	–	P	I	C	C	"Kesscoflex" DIOZ (48) "Morflex" 400 (52) "Plastolein"9057 DIOZ(29) "Staflex" DIOZ (21)	21,28,29,48, 52
27.	240-270 @ 20mm.	–	Ins.	P	P	C	C	C	C	C	–	C	C	"Plastomoll" TAH (10)	10
28.	238-247 @ 20 mm.	–	Ins.	–	–	–	–	–	–	–	–	–	C	"Plasticizer" 13 (10)	10
29.	230-242 @ 5 mm.	16-28	<0.01	P	C	C	C	C	C	C	C	C	C	"Benzoflex" 2-45 (69) "Kolflex" (49) "Plastoflex" DGB (1)	1, 49, 69
30.	225-235 @ 5 mm. 250 @ 10 mm.	<–35 –12	<0.01	P	C	C	C	C	C	C	C	C	C	"Benzoflex" 9-88 (69) "Kolflex" 312 (49) "Plastoflex" MGB (1)	1, 49, 69
31.	223-237 @ 1 mm.	47	0.05	P	C	C	C	–	C	C	C	C	C	"Benzoflex" T-150 (69)	69
32.	217-290 @ 1 mm.	<–35	0.08	I	C	C	C	–	C	C	C	C	C	"Benzoflex" P-200 (69)	69
33.	243-327 @ 1 mm.	<–35	0.14	I	C	C	C	–	C	C	C	C	C	"Benzoflex" P-300 (69)	69
34.	258 d. @ 1 mm.	<–35	0.70	I	C	C	C	–	C	C	C	C	C	"Benzoflex" P-400 (69)	69
35.	200 d. @ 1 mm.	3.8	0.78	I	C	C	C	–	C	C	C	C	C	"Benzoflex" P-600 (69)	69
36.	305	48	0.006	C	C	–	–	–	–	–	–	–	–	–	24, 31, 46, 55
37.	320-330	34.5	Ins.	C	C	C	C	–	C	C	C	C	C	Ortho-nitrobiphenyl ONB (50)	50

[a] Code for compatibility: C = compatible, P = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers.
[c] Measurement made at 20°C. [d] The trade marks for plasticizers are shown in quotation marks.
[e] Decomposes at temperatures in this range. [f] Pour point.

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25° C.	R. I. AT 25° C.	F. P.	V.P.
						°C.	*mm. Hg*
38. Chlorinated biphenyl	–	–	–	1.182–1.192	1.617–1.618	141–150	–
39. Chlorinated biphenyl	–	–	–	1.270–1.280	1.620–1.622	152–154	–
40. Chlorinated biphenyl	–	–	–	1.378–1.388	1.627–1.629^c	176–180	–
41. Chlorinated biphenyl	–	–	–	1.447–1.457	1.630–1.631^c	193–196	–
42. Chlorinated biphenyl	–	–	–	1.538–1.548	1.637–1.639^c	None	–
43. Chlorinated biphenyl	–	–	–	1.577–1.587	1.6501–1.6517	None	–
44. Chlorinated biphenyl	–	–	–	1.618–1.629	–	None	–
45. Chlorinated biphenyl	–	–	–	1.810	–	None	–
46. Chlorinated polyphenyl	–	–	–	1.670	1.664–1.667	None	–
47. Chlorinated polyphenyl	–	–	–	1.470	–	247	–
48. Chlorinated polyphenyl	–	–	–	1.670	1.660–1.665	None	–
49. Chlorinated polyphenyl	–	–	–	1.734	–	None	–
50. **Camphor**	$CH_2CH_2CHC(CH_3)_2C(CH_3)COCH_2$	$C_{10}H_{16}O$	152	0.990	–	93	38 @ 18°
Caprylic acid derivative							
51. Butanediol dicaprylate	$(CH_2)_2(CH_2OCOC_7H_{15})_2$	$C_{20}H_{38}O_4$	342	0.929^c	1.4420	–	–
Citric acid derivatives							
52. Triethyl citrate	$(C_2H_5OCOCH_2)_2C(OH)COOC_2H_5$	$C_{12}H_{20}O_7$	276	1.136	1.4405 @ 24.5°	155	–
53. Tri-*n*-butyl citrate	$(C_4H_9OCOCH_2)_2C(OH)COOC_4H_9$	$C_{18}H_{32}O_7$	360	1.049 @ 20°	1.4453^c	185	–
54. Acetyl triethyl citrate	$(C_2H_5OCOCH_2)_2C(OCOCH_3)COOC_2H_5$	$C_{14}H_{22}O_8$	318	1.135 @ 23°	1.4386 @ 23°	188	–
55. Acetyl tri-*n*-butyl citrate	$(C_4H_9OCOCH_2)_2C(OCOCH_3)COOC_4H_9$	$C_{20}H_{34}O_8$	402	1.046	1.4408 @ 25.5°	204	–
56. Acetyl tri-(2-ethylhexyl)citrate	$(C_8H_{17}OCOCH_2)_2C(OCOCH_3)COOC_8H_{17}$	$C_{32}H_{58}O_8$	571	0.983	1.441	224	–
Coconut oil derivatives							
57. Chlorinated coconut oil fatty acids	–	–	320	1.13	1.480	145	–
Epoxy derivatives							
58. Epoxy-type plasticizer	–	–	354	0.910^c	1.451	210	0.06 @ 150°
59. Epoxy-type plasticizer	–	–	–	0.991-0.994	1.471	232	–
60. Epoxy-type plasticizer	–	–	–	0.901	1.453	207	–
61. Epoxy-type plasticizer	–	–	420	0.923	1.457	232	–
62. Epoxy-type plasticizer	–	–	>950	0.994	1.472	310	–
63. Epoxy-type plasticizer	–	–	960	0.991	1.471	310	–
64. Epoxy-type plasticizer	–	–	–	0.922	1.4584	265	–
65. Epoxy-type plasticizer	–	–	–	0.909	1.452	–	–
66. Epoxy-type plasticizer	–	–	380	0.901	1.452	202	–
67. Epoxy-type plasticizer	–	–	ca. 1000	0.995	–	–	–
68. Epoxy-type plasticizer	–	–	> 800	0.9898	1.4719	310	<1 @ 330
69. Epoxy-type plasticizer	–	–	ca. 1000	0.999	1.471	316	–
70. Epoxy-type plasticizer	–	–	–	0.9180	–	–	–
71. Epoxy-type plasticizer	–	–	>1000	0.988	1.470	–	–
72. Epoxy-type plasticizer	–	–	>350	0.898	1.447	–	–
73. Epoxy-type plasticizer	–	–	425	0.922	1.457	216	–
74. Epoxy-type plasticizer	–	–	ca. 1000	0.998	1.472	315	–
75. Epoxy-type plasticizer	–	–	–	0.919	1.460	225	–
76. Epoxy-type plasticizer	–	–	>1000	0.998	1.471	315	–
77. Epoxy-type plasticizer	–	–	–	0.919	1.462	223	–
78. Epoxy-type plasticizer	–	–	–	0.900	1.450	265	–
79. Epoxy-type plasticizer	–	–	–	0.920	1.459	265	–
80. Epoxy-type plasticizer	–	–	–	0.923	1.457	260	–
81. Alkyl epoxy stearate	$C_8H_{17}CH\text{-}O\text{-}CH(CH_2)_7COOR$	–	–	0.899	1.4537	265	–
82. Alkyl epoxystearate (3.5% oxirane oxygen)	–	–	–	0.90	1.45	210	0.7 @ 200°C.
83. Alkyl epoxystearate (4.5% oxirane oxygen)	–	–	–	0.92	1.46	220	0.6 @ 200°C.
84. Epoxidized soybean oil	–	–	<950	0.996	1.472	310	–
Ether derivatives							
85. Dibenzyl ether	$(C_6H_5CH_2)_2O$	$C_{14}H_{14}O$	198	1.0428^c	–	–	–
86. Bis-alpha-methylbenzyl ether	$C_6H_5CH(CH_3)OCH(CH_3)C_6H_5$	$C_{16}H_{18}O$	226	1.0017	1.5408^c	135	<0.01 @ 20
87. Polyvinyl ethylether	 $\left[\begin{array}{l}-CH-CH_2-\\ \ \ \vert\\ \ \ O-C_2H_5\end{array}\right]_n$	$(C_4H_8O)_n$	ca. 10,000	0.94	1.450	–	–
88. Polyvinyl ethylether	 $\left[\begin{array}{l}-CH-CH_2-\\ \ \ \vert\\ \ \ O-CH_5\end{array}\right]_n$	$(C_4H_8O)_n$	ca. 32,000-34,000	1.09	1.455	–	–
Ethylhexoic acid derivative							
89. 2.2.'-(2-Ethylhexamido) diethyl di-(2-Ethylhexoate)	$(C_7H_{15}COOC_2H_4)_2NCOC_7H_{15}$	$C_{28}H_{53}NO_5$	484	0.9564^c	1.4584^c	216	0.5 @ 200°
Formal							
90. Dibutoxy-ethoxyethyl formal	$(C_4H_9OC_2H_4OC_2H_4O)_2CH_2$	$C_{17}H_{36}O_6$	336	0.97	–	–	–
Fumaric acid derivative							
91. Diphenoxyethyl fumarate	$(C_6H_5OC_2H_4OCO)_2C_2H_2$	$C_{20}H_{20}O_6$	356	1.08	–	–	–
92. Dibutyl fumarate	$C_2H_2(COOC_4H_9)_2$	$C_{12}H_{20}O_4$	228	0.986	1.444	138	–
93. Dioctyl fumarate	$C_2H_2(COOC_8H_{17})_2$	$C_{20}H_{36}O_4$	340	0.934	1.454	193	0.3 @ 100
Glycerol derivatives							
94. Glycerol monoacetate	$CH_3COOCH_2CHOHCH_2OH$	$C_5H_{10}O_4$	134	1.190	1.4535	148	–
95. Glycerol diacetate	$C_3H_5(OH)(OCOCH_3)_2$	$C_7H_{12}O_5$	176	1.186^c	–	146	–
96. Glycerol triacetate	$CH_3COOCH_2CH(OCOCH_3)CH_2OCOCH_3$	$C_9H_{14}O_6$	218	1.160	1.429	133	–
97. Glycerol tripropionate	$C_3H_5(OCOC_2H_5)_3$	$C_{12}H_{20}O_6$	260	1.078^c	1.431^c	–	–

*Code for column headings: Sp. Gr. = specific gravity; R. I. = refractive index; F. P. = flash point (Cleveland and Open Cup); V. P. = vapor pressure; B. R. = boiling range; M. P. = melting point; S. in water = solubility in water; CA = cellulose acetate; CAB = cellulose acetate butyrate; CN = cellulose nitrate; EC = ethyl cellulose; PM = polymethyl methacrylate; PS = polystyrene; VA = polyvinyl acetate; VB = polyvinyl butyral; VC = vinyl chloride; and VCA = vinyl chloride acetate.

	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS[a]										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS	MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA		
	°C.	°C.	*% by wt.*												
38.	275–320	–	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1221 (50)	50
39.	290–325	–	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1232 (50)	50
40.	322–365	–	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1242 (50)	50
41.	330–370	–	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1248 (50)	50
42.	365–390	–	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1254 (50)	50
43.	400–430	–	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1262 (50)	50
44.	385–420	–	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1260 (50)	50
45.	435–450	135–160	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 1268 (50)	50
46.	230–320 @ 4 mm.	60–66	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 4465 (50)	50
47.	215–300 @ 4 mm.	50–61	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 5442 (50)	50
48.	280–335 @ 4 mm.	100–105.5	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 5460 (50)	50
49.	–	66–72	Ins.	I	C	C	C	–	C	C	C	C	C	"Aroclor" 2565 (50)	50
50.	205–209	165–174(tech.) 174–178(USP)	0.170	C	C	C	–	–	–	–	–	–	–	–	27, 31
51.	211–222 @ 5 mm.	10.5	0.01	–	–	–	–	–	–	–	–	–	–	"RC" BD-8 (64)	64
52.	127 @ 1 mm.	–55	6.1[e]	C	C	C	C	–	P	C	C	C	C	"Citroflex" 2 (60), "Morflex" C2 (52)	51, 52, 60
53.	170 @ 1 mm.	–85	<0.002	C	C	C	C	–	C	C	C	C	C	"Citroflex" 4 (60), "Morflex" C4 (52)	24, 52, 60
54.	132 @ 1 mm.	–50	0.72	C	C	C	C	–	C	C	C	C	C	"Citroflex" A2 (60), "Morflex" C2A (52)	52, 60
55.	173 @ 1 mm.	–80	<0.002	P	P	C	C	–	C	C	C	C	C	"Citroflex" A4 (60), "Morflex" C4A (52)	52, 60
56.	225 @ 1 mm.	–	Ins.	I	I	P	P	I	–	I	I	C	C	"Citroflex" A8 (60), "Morflex" C8A (52)	52, 60
57.	Dec. @ 160	–20	Ins.	–	C	C	C	C	–	–	P	C	C	DP-520 (26)	26, 39
58.	200-250	–	<0.01	P	C	C	C	P	C	C	P	C	C	KP-90 (18)	18
59.	–	0-5	Ins.	I	I	C	C	–	–	I	–	C	C	PX-800 (61)	61
60.	235 @ 2 mm.	–	Ins.	–	C	C	C	–	–	I	–	C	C	"Admex" 745 (6)	6
61.	–	–	Ins.	I	C	–	C	–	–	I	–	C	–	"Admex" 746 (6)	6
62.	–	–	Ins.	–	P	C	C	I	I	–	–	C	C	"Admex" 711 (6)	6
63.	–	–	Ins.	–	P	C	C	I	I	I	I	C	C	"Admex" 710 (6)	6
64.	260 @ 2 mm.	–22	Ins.	–	C	C	C	–	–	–	–	C	C	"Drapex" 4.4 (7)	7
65.	–	–1	Ins.	–	–	–	–	–	–	–	–	–	–	"Monoplex" S-70 (63)	63
66.	238 @ 5 mm.	–2	Ins.	I	I	C	C	–	–	I	I	C	C	"Monoplex" S-71 (63)	63
67.	–	0-5	Ins.	P	P	C	C	–	–	P	–	C	C	"Paraplex" G-61 (63)	63
68.	–	0	Ins.	I	P	C	C	–	–	P	I	C	C	"Paraplex" G-60 (63)	63
69.	–	2	Ins.	I	I	C	C	I	I	I	I	C	C	"Paraplex" G-62 (63)	63
70.	–	–8	Ins.	–	–	–	–	–	–	–	–	–	–	"Monoplex" S-73 (63)	63
71.	–	–	Ins.	–	P	C	C	I	I	I	I	C	C	"Plastoflex" ESO (1)	1
72.	–	–	Ins.	P	C	C	C	P	C	C	P	C	C	"Plastoflex" EET (1)	1
73.	260 @ 2 mm.	–18	Ins.	–	C	C	C	–	–	–	–	C	C	"Estynox 408" (11)	11
74.	–	0-3	Ins.	I	P	P	C	P	–	–	I	C	C	"Peroxidol" 780 (62)	62
75.	–	–23	Ins.	–	C	C	C	–	–	–	–	C	C	"Peroxidol" 781 (62)	62
76.	–	3	Ins.	I	P	P	C	P	–	–	I	C	C	"Kolflex" 316 (49)	49
77.	–	–22	Ins.	–	C	C	C	–	–	–	–	C	C	"Kolflex" 317 (49)	49
78.	240 @ 2 mm.	–15	Ins.	–	C	C	C	–	–	–	–	C	C	"Plastolein" 9213 (29)	29
79.	260 @ 2 mm.	–23	Ins.	–	C	C	C	–	–	–	–	C	C	"Plastolein" 9214 (29)	29
80.	–	–22	Ins.	–	C	C	C	–	–	–	–	C	C	"PX" 806 (61)	61
81.	240 @ 2 mm.	–13.5	Ins.	–	C	C	C	–	–	–	–	C	C	"Drapex" 3.2 (7)	7
82.	213 @ 4 mm.	–13	–	I	C	C	C	I	P	–	–	C	C	"Celluflex" (17)	17
83.	226 @ 4 mm.	–17	–	I	C	C	C	I	P	–	–	C	C	"Celluflex" (17)	17
84.	–	–	Ins.	I	P	C	C	I	I	I	I	C	C	"EpoxyGen" 80 (34), "EpoxyGen" 90 (34)	34
85.	295-298	4-5	Ins.	–	–	–	–	–	–	–	–	–	–	"Plastoflex" DBE (1)	1
86.	286	–	Ins.	–	–	–	–	–	–	–	–	–	–	–	75
87.	–	–	Ins.	I	I	C	I	I	I	I	–	I	I	"Lutonal" A25 (10)	10
88.	–	–	Ins.	I	I	C	I	I	I	I	–	I	I	"Lutonal" A50 (10)	10
89.	256 @ 5 mm.	–33[f]	<0.01	I	C	C	C	I	–	I	C	C	C	"Flexol" 8N8 (72)	72
90.	–	–	–	–	–	–	–	–	–	–	–	–	–	"TP-90" B (70)	70
91.	–	125-127	Ins.	P	P	P	P	–	–	P	–	P	P	–	55
92.	285	–19	Ins.	–	–	–	–	–	–	C	–	C	C	"DBF" 774 (62)	62
93.	160 @ 10 mm.	–62	0.15% @ 25	–	–	–	–	–	–	C	–	C	C	"DOF" 773 (62)	62
94.	160-178 @ 30 mm.	<–30	∞	C	–	C	–	–	–	–	–	–	I	Acetin, "Kesscoflex" MOA (48)	24, 48
95.	142-153 @ 11 mm.	<–30	∞	C	–	C	–	–	–	–	–	–	I	Diacetin, "Kesscoflex" DIA (48)	24, 48
96.	259-262	–78	6.69	C	C	C	C	C	–	C	–	–	I	Triacetin, "Kesscoflex" TRA (48)	24, 28, 48, 51
97.	177-182 @ 20 mm.	<–50	0.313	C	C	C	C	–	–	C	–	–	–	Tripropionin	24

[a] Code for compatibility: C = compatible, P = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers.
[c] Measurement made at 20°C. [d] The trade marks for plasticizers are shown in quotation marks.
[e] Decomposes at temperatures in this range. [f] Pour point.

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25° C.	R. I. AT 25° C.	F. P.	V. P.
						°C.	mm. Hg
98. Glycerol tributyrate	$C_3H_5(OCOC_3H_7)_3$	$C_{15}H_{26}O_6$	302	1.035^c	1.4359^c	–	–
99. Glycerol ether acetate	–	$C_{21}H_{38}O_{12}$	482	1.140	1.445	155	–
Glycol derivatives							
100. Ethylene glycol dipropionate	$(CH_2OCOC_2H_5)_2$	$C_8H_{14}O_4$	174	1.054 @ 15°	1.419	–	–
101. Ethylene glycol dibutyrate	$(CH_2OCOC_3H_7)_2$	$C_{10}H_{18}O_4$	202	1.024 @ 0°	1.424	–	–
102. Diethylene glycol dipropionate	$(CH_3CH_2COOCH_2CH_2)_2O$	$C_{10}H_{18}O_5$	218	1.066^c	1.429	127	–
103. Triethylene glycol diacetate	$(CH_2OCH_2CH_2OCOCH_3)_2$	$C_{10}H_{18}O_6$	234	1.115	1.437	–	–
104. Triethylene glycol dipropionate	$(CH_2OCH_2CH_2OCOC_2H_5)_2$	$C_{12}H_{22}O_6$	262	1.066	1.436	–	$<0.01^c$
105. Triethylene glycol di-(2-ethylbutyrate)	$C_5H_{11}CO(OC_2H_4)_3OCOC_5H_{11}$	$C_{18}H_{34}O_6$	346	0.9946^c	1.4404^c	196	5.8 @ 200°
106. Triethylene glycol di-caprylate-caprate	–	–	400 avg.	0.965	1.4455	185	–
107. Triethylene glycol di-(2-ethylhexoate)	$C_7H_{15}CO(OC_2H_4)_3OCOC_7H_{15}$	$C_{22}H_{42}O_6$	403	0.9679^c	1.4441	207	1.85 @ 200°
108. Triethylene glycol dicaprylate	$(CH_2OCH_2CH_2OCOC_7H_{15})_2$	$C_{22}H_{42}O_6$	403	0.966	1.453	205	–
109. Tetraethylene glycol dicaprylate	$(C_7H_{15}COOCH_2CH_2OCH_2CH_2)_2O$	$C_{24}H_{46}O_7$	447	0.985	–	210	–
110. Polyethylene glycol di-(2-ethylhexoate)	$C_7H_{15}CO(OC_2H_4)_xOCOC_7H_{15}$ (X averages 4)	–	–	0.9892^c	1.4470^c	202	–
111. 1, 2, 6 – Hexanetriol	$HOCH_2CH(OH)(CH_2)_3CH_2OH$	$C_6H_{14}O_3$	134	1.1063^c	1.4771^c	191	<0.01
112. Polyethylene glycol 200	$HO(CH_2CH_2O)_xH$	–	200 avg.	1.125^c–1.127	1.4591^c	171	–
113. Polyethylene glycol 300	$HO(CH_2CH_2O)_xH$	–	300 avg.	1.125^c–1.127	1.4641^c	>204	–
114. Polyethylene glycol 400	$HO(CH_2CH_2O)_xH$	–	400 avg.	1.125^c–1.128	1.4661^c	>218	–
115. Polyethylene glycol 600	$HO(CH_2CH_2O)_xH$	–	600 avg.	1.125^c–1.128	1.468	>232	–
116. Polyethylene glycol 1000	$HO(CH_2CH_2O)_xH$	–	1000 avg.	1.085	–	>232	–
117. Polyethylene glycol 1500 and 550B	$HO(CH_2CH_2O)_xH$	–	550 avg.	1.151^h	–	221	–
118. Polyethylene glycol 1540 and 1450	$HO(CH_2CH_2O)_xH$	–	1300-1600	1.15^e	–	266	–
119. Polyethylene glycol 4000	$HO(CH_2CH_2O)_xH$	–	3000-4300	1.204^h	–	278	–
120. Polyethylene glycol 6000	$HO(CH_2CH_2O)_xH$	–	5400-7500	–	–	271	–
121. Polyethylene glycol 20M	$HO(CH_2CH_2O)_xH$	–	15,000-20,000	–	–	> 240	–
122. Polypropylene glycol 400	$HO(C_3H_6O)_xH$	–	400 avg.	1.007	1.4449	199	1.2 @ 25°
123. Polypropylene glycol 750	$HO(C_3H_6O)_xH$	–	750 avg.	1.004	1.4470	257	1.4 @ 25°
124. Polypropylene glycol 1200	$HO(C_3H_6O)_xH$	–	1200 avg.	1.003	1.4479	238	1.4 @ 25°
125. Polyalkylene glycol derivative	$R{-}O(C_3H_6O)_xH$	–	–	0.995	1.4487^c	221	0.8 @ 200°
126. Methyl phthalyl ethyl glycolate	$CH_3OCOC_6H_4COOCH_2COOC_2H_5$	$C_{13}H_{14}O_6$	266	1.220	1.504	193	–
127. Ethyl phthalyl ethyl glycolate	$C_2H_5OCOC_6H_4COOCH_2COOC_2H_5$	$C_{14}H_{16}O_6$	280	1.180	1.498	190	–
128. Butyl phthalyl butyl glycolate	$C_4H_9OCOC_6H_4COOCH_2COOC_4H_9$	$C_{18}H_{24}O_5$	336	1.097	1.490	199	–
129. Di (2-ethylhexyl) diglycolate	$O[CH_2{-}COO{-}CH_2{-}CH(C_2H_5)C_4H_9]_2$	$C_{20}H_{38}O_5$	358	0.961	1.445	–	–
130. Polyoxypropylene glycol ethylene oxide	$HO(C_2H_4O)_a(C_3H_6O)_b(C_2H_4O)_cH$	40-50% C_2H_4O	2000	1.05-1.06	–	–	–
131. Polyoxypropylene glycol ethylene oxide	$HO(C_2H_4O)_a(C_3H_6O)_b(C_2H_4O)_cH$	20-30% C_2H_4O	2000	1.025-1.035	–	–	–
132. Polyoxypropylene glycol ethylene oxide	$HO(C_2H_4O)_a(C_3H_6O)_b(C_2H_4O)_cH$	40-50% C_2H_4O	3000	1.04-1.05	–	–	–
133. Polyoxypropylene glycol ethylene oxide	$HO(C_2H_4O)_a(C_3H_6O)_b(C_2H_4O)_cH$	80-90% C_2H_4O	8000	–	–	–	–
Hydrocarbon							
134. Hydrocarbon, synthesized	–	–	300	0.873	1.4893	–	–
135. Hydrocarbon, synthesized	–	–	280	0.8715	1.4896	–	–
136. Hydrocarbon type	–	–	–	ca. 0.96-0.97	ca. 1.54-1.55	–	–
137. Hydrocarbon type	–	–	–	1.004-1.005	1.567-1.568	174	–
138. Hydrogenated triphenyl	–	–	–	1.001-1.007	1.560-1.575	174	–
139. Hydrocarbon type	–	–	–	1.02-1.07	1.6	121	–
140. Hydrocarbon type	–	–	400	0.960-0.975	1.590	210	–
141. Hydrocarbon type	$(CH_3)_2C_{10}H_5[CH_2C_{10}H_5(CH_3)_2]_x$	$CH_2C_{10}H_5(CH_3)_2$	662	1.09	1.591	–	–
142. Hydrocarbon type	–	–	–	1.051 @ 15.5°	–	–	–
143. Hydrocarbon type	–	–	245-275	0.8850	1.4836	130	–
144. Polyaromatic hydrocarbon oil	–	–	–	0.944 @ 15.6°	1.5556	146	–
145. Polyaromatic hydrocarbon oil	–	–	–	0.948 @ 15.6°	1.5568	149	–
146. Aromatic hydrocarbon condensate	–	–	230-250	1.06-1.09	1.60-1.62	>140	0.051 @ 26°
147. Aromatic hydrocarbon	–	–	321	0.9847	1.562 @ 20	185	–
148. Aromatic hydrocarbon	–	–	400	1.07	1.606	191	–
149. Aromatic hydrocarbon	–	–	412	0.9786 @ 15.6°	–	221	–
150. Hydrocarbon type	–	–	267	0.8899^c	1.49	135	–

*Code for column headings: Sp. Gr. = specific gravity; R. I. = refractive index; F. P. = flash point (Cleveland and Open Cup); V. P. = vapor pressure; B. R. = boiling range; M. P. = melting point; S. in water = solubility in water; CA = cellulose acetate; CAB = cellulose acetate butyrate; CN = cellulose nitrate; EC = ethyl cellulose; PM = polymethyl methacrylate; PS = polystyrene; VA = polyvinyl acetate; VB = polyvinyl butyral; VC = vinyl chloride; and VCA = vinyl chloride acetate.

	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS[a]										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS	MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA		
	°C.	*°C.*	*% by wt.*												
98.	315	<–75	0.010	C	C	C	–	–	–	–	–	–	–	Tributyrin	24, 28
99.	–	–41	–	C	C	C	C	I	I	C	–	I	–	"W-90" (10)	10
100.	211	<–80	0.160	C	C	C	C	–	–	–	–	–	–	Ethylene dipropionate	24
101.	240	<–80	0.050	C	C	C	C	–	–	–	–	–	–	Ethylene dibutyrate	24
102.	110–118 @ 4 mm.	–	3.60	C	C	C	C	–	–	–	–	–	–	–	24
103.	170–197 @ 20 mm.	<–60	>50	C	C	C	C	C	–	–	–	–	–	–	24
104.	138–142 @ 2 mm.	<–60	6.70	C	C	C	C	C	–	–	–	–	–	–	24
105.	196 @ 5 mm.	-65^f	0.02	I	C	C	C	C	–	C	C	C	C	"Flexol" 3GH (72)	72
106.	180–247 @ 2.5 mm.	–	Ins.	–	–	C	C	–	–	–	C	C	C	"Eldoplast" 45 (33), "Morflex" 800 (52), "RC" TG-85(64)	33, 52, 64
107.	219 @ 5 mm.	-65^f	<0.01	I	C	C	C	C	–	I	P	C	C	"Flexol" 3GO (72)	72
108.	227–278 @ 6 mm.	–5 to –15	<0.1	I	P	C	C	P	–	–	C	C	C	"Morflex" 801 (52), "RC" TG-8 (64), SC (26)	26, 39, 52, 64
109.	–	–43	Ins.	–	–	–	–	–	–	–	–	C	C	DP-200 (26)	26, 39
110.	250 @ 5 mm.	-55^f	<0.01	I	C	C	C	C	C	C	I	C	C	"Flexol" 4GO (72)	72
111.	178 @ 5 mm.	32.8^g	∞	–	–	C	–	–	–	–	–	–	–	–	72
112.	–	Super cools –65	∞	–	–	C	–	–	–	–	–	–	–	"Carbowax" 200 (72), P-4 (10), PEG 200 (45)	10, 45, 72
113.	–	–15 to 8	∞	–	–	C	–	–	–	–	–	–	–	"Carbowax" 300 (72), P-6 (10), PEG 300 (45)	10, 45, 72
114.	–	4-12	∞	–	–	C	–	–	–	–	–	–	–	"Carbowax" 400 (72), P-9 (10), PEG 400 (45)	10, 31, 45, 72
115.	–	20-25	∞	–	–	C	–	–	–	–	–	–	–	"Carbowax" 600 (72), P-13 (10), PEG 600 (45)	10, 45, 72
116.	–	37-40	70	–	–	C	–	–	–	–	–	–	–	"Carbowax" 1000 (72), PEG 1000 (45)	45, 72
117.	–	38-41	73	–	–	C	–	–	–	–	–	–	–	"Carbowax" 1500 (72), P-34 (10), PEG 550B (45)	10, 45, 72
118.	–	43-46	70	–	–	C	–	–	–	–	–	–	–	"Carbowax" 1540 (72), PEG 1450 (45)	45, 72
119.	–	55-59	62	–	–	C	–	–	–	–	–	–	–	"Carbowax" 4000 (72), PEG 4000 (45)	45, 72
120.	–	60-63	50	–	–	C	–	–	–	–	–	–	–	"Carbowax" 6000 (72), P-90 (10), PEG 6000 (45)	10, 45, 72
121.	–	50-55	Approx. 50	–	–	–	–	–	–	–	–	–	–	"Carbowax" 20M (72)	72
122.	–	–	∞	–	–	I	–	–	–	–	–	–	–	Polyglycol P 400 (25)	25
123.	–	–	15.5	–	–	I	–	–	–	–	–	–	–	Polyglycol P 750 (25)	25
124.	–	–	2	–	–	I	–	–	–	–	–	–	–	Polyglycol P 1200 (25)	25
125.	–	-37^f	0.1	–	–	–	–	–	–	–	–	–	–	"Flexol" B-400 (72)	72
126.	189 @ 5 mm.	–	0.053	C	C	C	C	C	C	C	C	C	C	"Santicizer" M-17 (50)	50
127.	190 @ 5 mm.	–	0.018	C	C	C	C	C	C	C	C	C	C	"Santicizer" E-15 (50)	50
128.	219 @ 5 mm.	–	0.001	C	C	C	C	C	C	C	C	C	C	"Santicizer" B-16 (50)	50
129.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	56
130.	–	12	Sol.	I	C	C	C	C	P	C	C	C	C	"Pluronic" L44 (75)	75
131.	–	–11	Sol.	I	C	C	C	C	P	C	C	C	C	"Pluronic" L62 (75)	75
132.	–	21	Sol.	I	C	C	C	C	I	C	I	C	C	"Pluronic" L64 (75)	75
133.	–	50	Sol.	C	I	C	I	C	I	I	I	I	I	"Pluronic" F68 (75)	75
134.	315-393	–	Ins.	–	–	–	–	–	–	C	–	P	P	"Conoco" H-300 (20)	20
135.	313-368	–	Ins.	–	–	–	–	–	–	C	–	P	P	"Conoco" H-35 (20)	20
136.	–	ca. 25	Ins.	–	–	–	C	–	–	–	–	C	–	AP-25 (59), HB-20 (50), "Piccocizer" 40 (59)	39, 50, 59
137.	340-396	–	Ins.	I	I	I	P	C	C	–	–	P	P	"Neville" R-29 (54), "Picco" 10 (39, 59)	39, 54, 59
138.	340-396	–	Ins.	I	C	C	C	–	C	C	C	C	C	HB-40 (50), Plasticizer 136 (2)	2, 50
139.	300-370	–	Ins.	–	C	P	C	C	C	–	P	C	C	"Nevinol" (54)	54
140.	–	25	Ins.	I	I	I	I	I	P	P	I	I	I	Aromatic Plasticizer 25 and 10 (59)	59
141.	>220 @ 2 mm.	85	Ins.	C	C	C	C	C	C	C	C	C	C	"Kenflex" A (47)	47
142.	–	–	Ins.	–	–	–	–	–	–	–	–	C	C	"Panaflex" BN-5 (5)	5
143.	–	–	Ins.	I	I	I	P	–	–	I	–	P	P	"Kolflex" 314 (49)	49
144.	290-379	–	Ins.	–	P	P	C	P	C	–	–	C	C	"Panaflex" BN-1 (5)	5
145.	303-388	–	Ins.	–	P	P	C	P	C	–	–	C	C	"Panaflex" BN-2 (5)	5
146.	300-370	5	Ins.	C	C	C	C	C	C	C	C	C	C	"Nevillac" 10° (54)	54
147.	327-382	2	Ins.	I	P	P	P	P	P	I	P	P	I	"Mobilsol" N (67)	67
148.	–	25	Ins.	I	I	I	I	P	C	C	I	I	I	"Picco" 25, "Picco" 10 (59)	59
149.	–	–	Ins.	–	–	–	–	–	–	–	–	C	C	"Mobilsol" K (67)	67
150.	–	–51	Ins.	I	I	–	P	I	I	I	P	P	P	"Mobilsol" L (67)	67

[a] Code for compatibility: C = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers. [c] Measurement made at 20°C.
[d] The trade marks for plasticizers are shown in quotation marks. [e] Decomposes at temperatures in this range. [f] Pour point.
[g] Freezes at this temperature under carefully controlled conditions. Under usual conditions, it sets to glass below –20°C. [h] Density, g/ml @ 20.

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25 °C.	R. I. AT 25 °C.	F. P.	V. P.
						°C.	*mm. Hg*
151. Aromatic hydrocarbon	–	–	270 avg.	1.014 @ 15.5°	1.577-1.597^c	182	–
152. Aromatic hydrocarbon	– –	–	325 avg.	1.032 @ 15.5°	1.590-1.630^c	212	–
Lauric acid derivatives							
153. Butyl laurate	$C_{11}H_{23}COOC_4H_9$	$C_{16}H_{32}O_2$	256	0.857^c	–	–	–
154. 1,2-Propylene glycol monolaurate	$C_{11}H_{23}COOCH_2CHOHCH_3$	$C_{15}H_{30}O_3$	258	0.911	–	–	–
155. Ethylene glycol monoethyl ether laurate	$C_{11}H_{23}COO(CH_2)_2OC_2H_5$	$C_{16}H_{32}O_3$	272	0.89	–	–	–
156. Ethylene glycol monobutyl ether laurate	$C_{11}H_{23}COO(CH_2)_2OC_4H_9$	$C_{18}H_{36}O_3$	300	0.883	–	–	–
157. Glycerol monolaurate	$C_{11}H_{23}COOCH_2CHOHCH_2OH$	$C_{15}H_{30}O_4$	274	0.970	–	–	–
158. Diethylene glycol monolaurate	$C_{11}H_{23}COOC_2H_4OC_2H_4OH$	$C_{16}H_{32}O_4$	288	0.960	–	–	–
159. Polyethylene glycol 400 dilaurate	$C_{11}H_{23}CO(OC_2H_4)_xCOOC_{11}H_{23}$	–	756	0.97	–	–	–
Maleic acid derivative							
160. Di-*n*-butyl maleate	$C_4H_9OCOCH:CHCOOC_4H_9$	$C_{12}H_{20}O_4$	228	0.9944	–	–	–
Myristic acid derivatives							
161. Isopropyl myristate	$C_{13}H_{27}COOCH(CH_3)_2$	$C_{17}H_{34}O_2$	270	0.849	1.432	146	–
162. *n*-Butyl myristate	$C_{13}H_{27}COOC_4H_9$	$C_{18}H_{36}O_2$	284	0.861	1.4394	174	–
163 Ethylene glycol monomethyl ether myristate	$C_{13}H_{27}COOCH_2CH_2OCH_3$	$C_{17}H_{34}O_3$	286	0.895	1.4406	174	–
Naphthalene derivatives							
164. Mixed amylnaphthalenes	–	$C_{10}H_{8-n}(C_5H_{11})_n$	–	0.92-0.94	1.5452	149	<0.01
165. Dinonylnaphthalene	$C_{10}H_6(C_9H_{19})_2$	$C_{28}H_{44}$	381	0.946^c	1.549^c	174	0.004@25°
Nitrile derivative							
166. Fatty acid nitrile	–	–	263	0.847	1.462@30°	180	1.0@140°
Oleic acid derivatives							
167. Methyl oleate	$C_{17}H_{33}COOCH_3$	$C_{19}H_{36}O_2$	296	0.870	1.4505	177	–
168. *n*-Propyl oleate	$C_{17}H_{33}COOC_3H_7$	$C_{21}H_{40}O_2$	324	0.869	1.4494	–23	–
169. Isopropyl oleate	$C_{17}H_{33}COOCH(CH_3)_2$	$C_{21}H_{40}O_2$	324	0.866	–	–	–
170. Butyl oleate	$C_{17}H_{33}COOC_4H_9$	$C_{22}H_{42}O_2$	339	0.865	1.451^c	180	–
171. Amyl oleate	$C_{17}H_{33}COOC_5H_{11}$	$C_{23}H_{44}O_2$	353	0.876	1.4545	186	<0.01
172. Octyl fatty acid esters	–	–	395	0.864	1.4520	210	<0.06@150°
173. Ethylene glycol monomethyl ether oleate	$C_8H_{17}CH=CH(CH_2)_7COOC_2H_4OCH_3$	$C_{21}H_{40}O_3$	341	0.895-0.902 @20°	1.453-1.455	197	0.23@150°
174. 1,2-Propylene glycol monooleate	$C_{17}H_{33}COOCH_2CHOHCH_3$	$C_{21}H_{40}O_3$	341	0.91-0.92	–	–	–
175. Ethylene glycol monobutyl ether oleate	$C_{17}H_{33}COOCH_2CH_2OC_4H_9$	$C_{24}H_{46}O_3$	382	0.887	–	–	–
176. Tetrahydrofurfuryl oleate	$C_{17}H_{33}COOCH_2 \cdot OC_4H_7$	$C_{23}H_{42}O_3$	367	0.921-0.923	1.4622	210	–
177. Glycerol monooleate	$C_{17}H_{33}COOCH_2CHOHCH_2OH$	$C_{21}H_{40}O_4$	357	0.945	–	–	–
178. Diethylene glycol monooleate	$C_{17}H_{33}COOC_2H_4OC_2H_4OH$	$C_{22}H_{42}O_4$	371	0.938	–	–	–
179. Diethylene glycol monoethyl ether oleate	$C_{17}H_{33}COO(CH_2CH_2O)_2C_2H_5$	$C_{24}H_{46}O_4$	399	0.957	–	–	–
Palmitic acid derivatives							
180. Isopropyl palmitate	$C_{15}H_{31}COOCH(CH_3)_2$	$C_{19}H_{38}O_2$	299	0.830-0.850	1.425-1.445	–	–
181. *n*-Butyl palmitate	$C_{15}H_{31}COOC_4H_9$	$C_{20}H_{40}O_2$	313	0.865	1.4429	185	–
182. Isooctyl palmitate	$C_{15}H_{31}COOC_8H_{17}$	$C_{24}H_{48}O_2$	369	0.863^c	–	213	–
183. Tetrahydrofurfuryl palmitate	$C_{15}H_{31}COOCH_2 \cdot OC_4H_7$	$C_{21}H_{40}O_3$	341	–	–	–	–
Paraffin derivatives							
184. Chlorinated paraffin	–	$C_{20}H_{37}Cl_5$	455	1.13-1.14	1.500	None	–
185. Chlorinated paraffin	–	$C_{25}H_{45}Cl_7$	594	1.162-1.175	–	None	–
186. Chlorinated paraffin	–	$C_{24}H_{43}Cl_7$	580	1.13-1.17	1.504	None	–
187. Chlorinated paraffin	–	$C_{20}H_{34}Cl_8$	556	1.18	1.518	None	–
188. Chlorinated paraffin	–	$C_{24}H_{29}Cl_{21}$	1060	1.16-1.17	1.535	None	–
Pelargonic acid derivatives							
189. Diethylene glycol dipelargonate	$(C_8H_{17}COOC_2H_4)_2O$	$C_{22}H_{42}O_5$	362	0.966^c	1.445-1.446	210	–
190. Triethylene glycol dipelargonate	$(CH_2OCH_2)_2(CH_2OCOC_8H_{17})_2$	$C_{24}H_{46}O_6$	431	0.964^c	–	216	–

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	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS[a]										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS	MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA		
	°C.	°C.	*% by wt.*												
151.	135-240	–	Ins.	P	P	P	C	–	C	–	C	C	P	"Dutrex" 25 (65)	65
152.	163-275	–	Ins.	I	P	P	C	–	C	–	C	C	P	"Dutrex" 20V (65)	65
153.	175-260 @ 20 mm.	0	Ins.	–	C	C	C	–	C	–	C	C	–	"Kesscoflex" BL (48)	26, 32, 48, 52
154.	–	0-12	Ins.	–	–	C	C	–	C	–	C	C	–	"Nopco" (56)	26, 34, 48, 52, 56
155.	–	–7 to –11	Ins.	–	C	C	C	–	C	–	C	C	–	Ethoxyethyl laurate	52
156.	156-198 @ 5 mm.	–3 to –12	Ins.	–	C	C	C	–	C	–	C	C	C	Butoxyethyl laurate, "Kesscoflex" BCL (48)	48, 52
157.	–	26-28	Ins.	–	–	C	C	–	C	–	C	C	C	"Morpel" X-574 (52)	26, 30, 34, 48, 52
158.	–	9-11	Ins.	–	–	C	C	–	–	–	C	–	C	"Glaurin" (34) "Morpel" X-870 (52) "Nopalcol" I-L (56) "Witco" DGL (74)	1, 26, 34, 48, 52, 56, 74
159.	–	4-14	Ins.	–	–	C	–	–	–	–	–	C	C	"Morpel" X-928 (52)	34, 48, 52, 56
160.	281	<–80	–	–	–	–	–	–	–	C	–	–	–	"RC" DBM (64)	2, 55, 64
161.	–	–	–	–	C	C	C	–	–	–	–	–	–	–	9, 48, 55
162.	180	3	Ins.	I	C	C	C	–	C	–	–	–	I	–	9, 48, 55
163.	175-180	15	Ins.	I	C	C	C	–	C	–	C	C	–	–	55
164.	290-400	–	Ins.	–	C	–	–	–	–	–	–	–	–	"Morpel" X-929 (52), "Pentalene" 195 (58)	52, 58
165.	200-270 @ 20 mm.	–	Ins.	I	I	C	C	I	C	–	I	–	C	"Morpel" X-841 (52)	52
166.	330-360	–4	Ins.	–	C	–	–	–	–	C	C	C	C	"Arneel" SD (8), OLN (39)	8, 39
167.	167-170 @ 2 mm.	13	Ins.	I	P	C	C	P	C	P	P	P	P	"Eldo" (33), "Emery" 2301 (29), "Nopco" 2060 (56)	1, 9, 29, 33, 56, 69
168.	181-189 @ 2 mm.	–	Ins.	I	P	C	C	P	C	P	P	P	P	"Emery" 2302 (29)	29, 38, 48, 55
169.	173-181 @ 2 mm.	–	Ins.	I	P	C	C	–	C	–	–	P	P	"Morflex" IPO (52)	38, 48, 52
170.	190-230 @ 6.5 mm.	<–10	Ins.	I	C	C	C	–	C	C	C	C	I	"Harflex" BO (38) "Kesscoflex" BO (48) "Morpel" X-930 (52) "Nopco" 2067-A (56) "RC" butyl oleate (64) "Witcizer" 100-101 (74)	1, 9, 18, 32, 38, 39, 48, 52, 56
171.	200-240 @ 20 mm.	<–40	Ins.	–	–	C	C	–	–	–	C	C	–	–	52
172.	210-239 @ 4 mm.	–	Ins.	I	I	C	C	P	C	P	C	P	–	"Ohopex" R-9 (18)	18, 48
173.	198-225 @ 4 mm.	–40	Ins.	I	C	C	C	–	P	P	C	C	C	Methoxyethyl oleate, "Kesscoflex" MCO (48) Kapsol (18)	18, 48
174.	–	–19 to –22	Ins.	–	–	C	C	–	–	–	–	C	–	–	30, 34, 48, 52
175.	192-221 @ 2 mm.	<–45	Ins.	–	–	C	C	–	–	–	–	C	–	Butoxyethyl oleate, "Kesscoflex" BCO (48)	34, 48, 52
176.	240 @ 5 mm.	–25	Ins.	P	C	C	C	C	C	C	–	C	C	"Plastolein" 9250 (29), "Plastoflex" VS (1)	1, 29
177.	–	18	Ins.	P	P	P	P	P	P	P	P	P	P	"Emery" 2221 (29) "Morpel" X-570 (52) "Witco" GMO (74)	26, 29, 30, 34, 38, 48, 52, 68, 74
178.	–	<–10	Ins.	–	–	C	C	–	–	–	–	–	–	"Morpel" X-565 (52), "Witco" DGO (74) "Nopalcol" I-O (56)	1, 30, 34, 38, 48, 52, 56, 74
179.	–	0 to –15	Ins.	–	–	C	C	–	–	–	–	–	–	–	31
180.	–	–	–	–	–	C	C	–	–	–	–	–	–	–	9, 48
181.	215-265 @ 20 mm.	0 to 9	Ins.	I	C	C	C	–	C	–	–	–	I	–	32, 48, 56
182.	218-235 @ 5 mm.	6-9	Ins.	I	I	C	C	–	C	–	–	I	I	"RC" 0-16 (64)	48, 49, 52, 64
183.	195 @ 1.5 mm.	–	Ins.	–	C	–	–	–	–	–	–	–	–	–	24
184.	–	–	Ins.	P	C	P	C	C	C	C	P	C	C	"Chlorowax" LV (23)	23
185.	–	–	Ins.	P	P	P	C	C	C	C	P	C	C	"Clorafin" 42 (41) CP-40 (42) "Stan-Chlor-Oil" (39) W-40 (10)	10, 39, 41, 42
186.	–	–	Ins.	P	C	P	C	C	C	C	P	C	C	"Cereclor" 42 (44), "Chlorowax" 40 (23)	14, 23, 44
187.	–	–	Ins.	P	C	P	C	C	C	C	P	C	C	"Chlorowax" 50 (23), W-50 (10)	10, 23
188.	–	–	Ins.	C	C	P	C	C	C	C	P	C	C	"Chlorowax" 70 (23)	23
189.	229 @ 5 mm.	–40	Ins.	I	C	C	C	–	I	P	C	C	C	"Morpel" X-931(52), "Plastolein" 9055 DGP (29), "RC" DG-9 (64)	29, 52, 64
190.	225-255 @ 5 mm.	+1 to –4	0.1	I	P	C	C	P	–	–	C	C	C	"Plastolein" 9404 TGP (29), "RC" TG-9 (64)	29, 52, 64

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[a] Code for compatibility: C = compatible, P = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers.
[c] Measurement made at 20 °C. [d] The trade marks for plasticizers are shown in quotation marks.
[e] Decomposes at temperatures in this range. [f] Pour point

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25° C.	R. I. AT 25° C.	F. P.	V. P.
						°C.	*mm. Hg*
Pentaerythritol derivative							
191. Pentaerythritol fatty acid ester	–	–	–	0.997	1.453	247	0.27@200°
Phosphoric acid derivatives							
192. Triethyl phosphate	$(C_2H_5O)_3PO$	$C_6H_{15}O_4P$	182	1.065-1.072^c	1.4055^c	116	10@73°
193. Tributyl phosphate	$(C_4H_9O)_3PO$	$C_{12}H_{27}O_4P$	266	0.973-0.983^c	1.4226^c	193	–
194. Tri-(2-ethylhexyl) phosphate	$[C_4H_9CH(C_2H_5)CH_2O]_3PO$	$C_{24}H_{51}O_4P$	435	0.9260^c	1.4434^c	207	1.9 @ 200°
195. Tributoxyethyl phosphate	$(C_4H_9OC_2H_4O)_3PO$	$C_{18}H_{39}O_7P$	398	1.020	1.434	222	<0.10@150°
196. Triphenyl phosphate	$(C_6H_5O)_3PO$	$C_{18}H_{15}O_4P$	326	1.185	1.563	225	–
197. Cresyl diphenyl phosphate	$(CH_3C_6H_4O)(C_6H_5O)_2PO$	$C_{19}H_{14}O_4P$	337	1.208	1.560	232	5.0@220°
198. Tricresyl phosphate	$(CH_3C_6H_4O)_3PO$	$C_{21}H_{21}O_4P$	368	1.165-1.168^c 1.145	1.553-1.556	230-235	<0.02@150°
199. Tri-dimethylphenyl phosphate	$[(CH_3)_2C_6H_3O]_3PO$	$C_{24}H_{27}O_4P$	410	1.145	1.5535	233	<0.01@20°
200. Alkyl phosphate ester	(Plas. for polyvinyl alcohol)	–	–	1.122^c	1.448	63	–
201. Alkyl aryl phosphate	$(C_8H_{17}O)(C_6H_5O)_2PO$	$C_{20}H_{27}O_4P$	362	1.089-1.093	1.507-1.510	224	1@153°
202. Diphenyl mono-*o*-xenyl phosphate	$(C_6H_5O)_2(C_6H_5C_6H_4O)PO$	$C_{24}H_{19}O_4P$	402	1.20@60°	1.582-1.590 @60°	225	–
203. Tri-*p*-*tert*-butylphenyl phosphate	$[(CH_3)_3CC_6H_4O]_3PO$	$C_{30}H_{39}O_4P$	495	–	–	275	–
204. Diethyl ethylphosphonate	$C_2H_5P(O)(OC_2H_5)_2$	$C_6H_{15}O_3P$	166	1.025^c	1.4148^c	105	–
205. Dibutyl butylphosphonate	$C_4H_9P(O)(OC_4H_9)_2$	$C_{12}H_{27}O_3P$	250	0.948^c	1.4310^c	155	–
206. Bis(2-ethylhexyl) 2-ethylhexylphosphonate	$C_8H_{17}P(O)(OC_8H_{17})_2$	$C_{24}H_{51}O_3P$	419	0.908^c	1.4481^c	215	–
207. O, O, O-triethyl phosphorothioate	$(C_2H_5O)_3PS$	$C_6H_{15}O_3PS$	198	1.074	1.4458	107	–
208. O, O, O-tributyl phosphorothioate	$(C_4H_9O)_3PS$	$C_{12}H_{27}O_3PS$	282	0.987	1.4491	146	–
209. O, O, O-triisoöctyl phosphorothioate	$(C_8H_{17}O)_3PS$	$C_{24}H_{51}O_3PS$	451	0.933	1.4580	210	–
210. Tris(2-chloroethyl) phosphite	$(CLCH_2CH_2O)_3P$	$C_6H_{12}O_3CL_3P$	270	1.353^c	1.4858	191	–
211. Trichloro ethyl phosphate	$(CLCH_2CH_2O)_3PO$	$C_6H_{12}O_4CL_3P$	286	1.425^c	–	246	–
212. Trisdichloropropyl phosphate	–	–	430	1.513	1.5018	249	–
Phthalic acid derivatives							
213. Dimethyl phthalate	$C_6H_4(COOCH_3)_2$	$C_{10}H_{10}O_4$	194	1.189-1.191 1.192-1.194^c	1.5168^c	146	<0.01^c
214. Diethyl phthalate	$C_6H_4(COOC_2H_5)_2$	$C_{12}H_{14}O_4$	222	1.118-1.123^c	1.5019^c	152	–
215. Dipropyl phthalate	$C_6H_4(COOC_3H_7)_2$	$C_{14}H_{18}O_4$	250	1.071	1.494	–	<0.01^c
216. Dibutyl phthalate	$C_6H_4(COOC_4H_9)_2$	$C_{16}H_{22}O_4$	278	1.042	1.4926^c	170-175	1.1@150°
217. Di-isobutyl phthalate	$C_6H_4[COOCH_2CH(CH_3)_2]_2$	$C_{16}H_{22}O_4$	278	1.040^c	1.4900	174	–
218. Diamyl phthalate	$C_6H_4(COOC_5H_{11})_2$	$C_{18}H_{26}O_4$	306	1.022	1.488^c	171	–
219. Dihexyl phthalate (n or iso)	$C_6H_4(COOC_6H_{13})_2$	$C_{20}H_{30}O_4$	334	0.990-0.994	–	199	–
220. Dimethylisobutylcarbinyl phthalate	$C_6H_4[COOCH(CH_3)CH_2CH(CH_3)_2]_2$	$C_{20}H_{30}O_4$	334	0.983	1.4764	–	–
221. Butyl octyl phthalate	$C_4H_9OCOC_6H_4COOC_8H_{17}$	$C_{20}H_{30}O_4$	334	1.005-1.011^c	1.4837	188	–
222. Butyl octyl phthalate	–	–	377	0.989	1.4850	199	–
223. Butyl isodecyl phthalate (Decyl butyl phthalate)	$C_4H_9OCOC_6H_4COOC_{10}H_{21}$	$C_{22}H_{34}O_4$	363	0.992-0.998	–	193	–
224. Butyl iso-hexyl phthalate	$(COOC_4H_9)C_6H_4(COOC_6H_{13})$	$C_{18}H_{26}O_4$	306	1.026	1.4880	174	–
225. Amyl isodecyl phthalate (Decyl amyl phthalate)	$C_5H_{11}OCOC_6H_4COOC_{10}H_{21}$	$C_{23}H_{36}O_4$	377	0.98	1.482	–	–
226. Di-*n*-octyl phthalate	$C_6H_4(COOC_8H_{17})_2$	$C_{24}H_{38}O_4$	391	0.978^c	1.482	219	<0.20@150°
227. Di-isooctyl phthalate	$C_6H_4(COOC_8H_{17})_2$	$C_{24}H_{38}O_4$	391	0.981	1.484	210	1.0@200°

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*Code for column headings: Sp. Gr. = specific gravity; R. I. = refractive index; F. P. = flash point (Cleveland and Open Cup); V. P. = vapor pressure; B. R. = boiling range; M. P. = melting point; S. in water = solubility in water; CA = cellulose acetate; CAB = cellulose acetate butyrate; CN = cellulose nitrate; EC = ethyl cellulose; **PM = polymethyl** methacrylate; PS = polystyrene; VA = polyvinyl acetate; VB = polyvinyl butyral; VC = vinyl chloride; and VCA = vinyl chloride acetate.

	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS	MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA		
	°C.	°C.	% by wt.												
191.	261 @ 4 mm.	–	–	I	–	C	C	I	P	I	P	C	C	"Hercoflex" 600 and "Hercoflex" 700 (41)	41
192.	216	–56	∞	C	C	C	C	C	C	–	C	–	C	–	28
193.	177-178 @ 27 mm.	<–80	0.60	C	C	C	C	C	C	C	C	P	C	–	18, 19
194.	220 @ 5mm.	–74[f]	<0.01	P	P	C	C	I	–	I	C	C	C	"Flexol" TOF (72)	72
195.	215-228 @ 4 mm.	<–70	0.1	C	P	C	C	C	P	C	C	C	C	KP-140 (18)	18
196.	220 @ 5 mm.	49.2	0.002 @ 54°	C	C	C	C	C	C	C	I	C	C	"Celluflex" TPP (17)	3, 4, 17, 24, 25, 50, 51
197.	390	–40	Ins.	P	C	C	C	–	I	I	C	C	C	"Celluflex" 112 (17), "Kronitex" MX (18) "Kolflex" (49), "Santicizer" 140 (50)	17, 18, 39, 49, 50, 51
198.	265-285 @ 10 mm.	<–35	Ins.	C	C	C	C	P	C	C	C	C	C	"Celluflex" 179-EG 179C (17), "Lindol" (17) "Kolflex" (49) "PX"-917 (61) "Kronitex" (18)	3, 17, 18, 24, 39, 49, 50, 51, 53, 61
199.	225-295 @ 10 mm.	–35 (pour pt.)	0.002 @ 25°	P	C	C	C	P	P	C	C	–	C	Trixylenyl phosphate, "Celluflex" 179-A (17) "Kronitex" K3 (18)	17, 18, 39, 51
200.	–	–	Sol.	–	–	–	–	–	–	–	–	–	–	"V-C" 1-318-19 (73)	73
201.	230 @ 5 mm.	–	–	P	C	–	C	–	C	C	C	C	C	"Santicizer" 141 (50)	50
202.	250-285 @ 5 mm.	–	Ins.	P	C	C	C	C	C	C	C	C	C	Dow P-5 (25)	25
203.	320 @ 5 mm.	95	Ins.	I	C	C	C	–	C	–	–	C	C	Dow P-77 (25)	25
204.	82-83 @ 11 mm.	–	Sol.	–	–	–	–	–	–	–	–	–	–	–	73
205.	127-128 @ 2.5 mm.	–	Ins.	–	–	–	–	–	–	–	–	–	–	–	73
206.	160-161 @ 0.25 mm.	–	Ins.	–	–	–	–	–	–	–	–	–	–	–	73
207.	93.5-94 @ 10 mm.	–	Ins.	–	–	C	C	–	–	–	–	–	–	–	73
208.	142-145 @ 4.5 mm.	–	Ins.	–	–	C	C	–	–	–	–	–	–	–	73
209.	160-170 @ 0.2 mm.	–	Ins.	–	–	C	C	–	–	–	–	–	–	–	73
210.	119 @ 0.15 mm.	–	Ins.	–	–	–	–	–	–	–	–	C	C	–	73
211.	203 @ 10 mm.	–60	0.7	C	C	C	C	–	C	C	C	C	C	"Celluflex" CEF (17)	17
212.	–	–	–	–	–	–	–	–	–	–	–	C	C	"Celluflex" FR-2 (17)	17
213.	282	0 5.5	0.45 @ 25°	C	C	C	C	C	C	C	C	P	C	"DMP" 771 (62) "Palatinol" M (10)	38, 40, 46, 49, 50, 62
214.	296	–40 –4	0.09 @ 25°	C	C	C	C	C	C	C	C	P	C	"DEP" 770 (62), "Witcizer" 322 (74) "Palatinol" A (10)	2, 10, 24, 28, 31, 40, 46, 49, 50, 51, 62, 71, 74
215.	129-132 @ 1 mm.	–	0.015	C	C	–	–	–	–	–	–	–	–	–	24
216.	339 227-235 @ 37 mm.	–35	Ins.	C	C	C	C	C	C	C	C	C	C	"Celluflex" DBP (17) "Darex" DBP (22) DBP 705 (62) "Griffin" DBP (36) "Harflex" 140 (38) "Kolflex" (49) "Morflex" 140 (52) "Palatinol" C (10) "Polycizer" DBP (39) "PX"-104 (61) "RC" DBP (64) "Staflex" DBP (21) "Witcizer" 300 (74)	2, 4, 10, 13, 17, 18, 19, 21, 22, 24, 28, 31, 36, 38, 39, 40, 49, 50, 51, 52, 53, 61, 62, 64, 66, 71, 74
217.	327	–50	<0.01	–	C	C	C	–	C	C	C	C	–	–	10, 28, 38, 40, 51
218.	342	<–55	0.01	I	C	C	C	C	–	C	C	P	C	–	10, 24, 40, 49, 71
219.	210 @ 5 mm.	–	Ins.	P	C	C	C	C	C	C	C	C	C	"Harflex" 160 (38), "Morflex" 160 (52), "RC" DIPH (64)	38, 52, 64
220.	190-195 @ 5 mm.	–	Ins.	P	C	C	C	C	C	C	C	C	C	"Plastoflex" 520 (1)	1
221.	340 @ 740 mm.	–50	<0.04	–	–	–	–	–	–	–	–	–	–	"BOP" 750 (62), "Elastex" 48-P (2), "RC" BOP (64)	2, 28, 40, 49, 62, 64
222.	225 @ 5 mm.	–	Ins.	I	P	C	C	C	C	C	C	C	C	"PX"-914 (61)	61
223.	220 @ 5 mm.	–45	Ins.	–	–	–	–	–	C	–	–	C	C	BDP 710 (62) "Elastex" 40-P (2) "Kolflex" (49) "Morflex" 135 (52) "PX"-114 (61) "RC" BIDP (64) "Santicizer" 603 (50) "Staflex" BDP (21)	2, 4, 21, 40, 49, 50, 52, 53, 61, 62, 64
224.	190-205 @ 5 mm.	–50	Ins.	P	C	C	C	C	C	C	C	C	C	"RC" BIHP (64)	64
225.	–	–	–	–	–	–	–	–	–	–	–	C	C	"Witcizer" 316 (74)	21, 74
226.	220-248 @ 4 mm.	–25	Ins.	I	C	C	C	C	C	I	C	C	C	"Morflex" X-926 (49)	4, 22, 40, 51, 52, 67
227.	239 @ 5 mm.	–45	Ins.	I	P	C	C	C	P	C	P	C	C	"Darex" DIOP (22) "D.I.O.P." (18) DIOP 735 (62) "Elastex" 10-P (2) "Griffin" DIOP (36) "Harflex" 120 (38) "Hercoflex" 200 (41) "Kolflex" (49) "Morflex" 100 (52) "PX"-108 (61) "RC" DIOP (64) "Staflex" DIOP (21) "Witcizer" 313 (74)	2, 3, 13, 18, 21, 22, 28, 36, 38, 40, 41, 49, 50, 51, 52, 53, 61, 62, 64, 66, 71, 74

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[a] Code for compatibility: C = compatible, P = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers.
[c] Measurement made at 20 °C. [d] The trade marks for plasticizers are shown in quotation marks.
[e] Decomposes at temperatures in this range. [f] Pour point.

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25°C.	R. I. AT 25°C.	F. P.	V. P.
						°C.	mm. Hg
228. Dicapryl phthalate	$C_6H_4(COOC_8H_{17})_2$	$C_{24}H_{38}O_4$	391	0.965-0.978	1.480^c	201-2061	–
229. Mixed alcohol phthalate	Blended alcohol (average 8-carbon) phthalate	$C_{24}H_{38}O_4$	391	0.9861^c	1.4844	–	–
230. Mixed alcohol phthalate	$C_6H_4(COOR)_2$ $R = C_8H_{17}n.C_{10}H_{21}$	–	ca. 400	0.975	1.483	–	–
231. Di-(2-ethylhexyl) phthalate	$C_6H_4(COOC_8H_{17})_2$	$C_{24}H_{38}O_4$	391	0.9861	1.4859^c 1.483	218 210	1.32 @ 200°
232. Di-(2-ethylhexyl) hexahydrophthalate	$C_6H_{10}[COOCH_2CH(C_2H_5)C_4H_9]_2$	$C_{24}H_{44}O_4$	397	0.9586^c	1.4619^c	218	2.2@200°
233. Dinonyl phthalate	$C_6H_4(COOC_9H_{19})_2$	$C_{26}H_{42}O_4$	419	0.965-0.972	1.4812	–	–
234. *n*-Octyl-*n*-decyl phthalate	$C_8H_{17}OCOC_6H_4COOC_{10}H_{21}$	$C_{26}H_{42}O_4$	419	0.968	1.481	228	–
235. Octyl decyl phthalate (Isooctyl isodecyl phthalate) (Isooctyl decyl phthalate)	$C_8H_{17}OCOC_6H_4COOC_{10}H_{21}$	$C_{26}H_{42}O_4$	419	0.967-0.977	1.481-1.485	228-232	0.01@150°
236. Di-decyl phthalate (Di-isodecyl phthalate)	$C_6H_4(COOC_{10}H_{21})_2$	$C_{28}H_{46}O_4$	447	0.9656^c	1.4835^c	231	–
237. Blend (50/50) of di-octyl and di-octyl-decyl phthalates	–	–	400	0.974	1.483	218	–
238. Blend (50/50) of di-octyl and di-decyl phthalates	–	–	–	0.972	1.4835	–	–
239. Ethylhexyldecyl phthalate	–	–	–	0.9729^c	1.4851^c	229	0.54 @ 200°
240. Butyl ethylhexyl phthalate	–	–	–	0.9941^c	1.4868	210	1.8 @ 200°
241. Mixed alkyl phthalates	Blend of 2/3 DIDP and 1/3 BBP	–	–	1.004-1.014	–	–	–
242. Mixed alkyl phthalate	Blend of 1/2 DIDP and 1/2 BBP	–	–	1.029-1.039	–	–	–
243. Mixed alkyl phthalate	Blend of 1/3 DIDP and 2/3 BBP	–	–	1.005-1.065	–	–	–
244. Mixed alkyl phthalate	Blend of di-isooctyl and di-*n*-octyl-*n*-decyl phthalate	–	400	0.973	1.482	218	–
245. Alkyl phthalate	–	–	–	0.956	–	–	–
246. Fatty acid phthalate	–	–	–	0.952^c	1.478	224	<0.06@150°
247. Di (2-ethylhexyl) + Su phthalate	–	–	–	0.9840^c	1.4875^c	232	0.69@200°
248. Diallyl phthalate	$C_6H_4(COOCH_2CH = CH_2)_2$	$C_{14}H_{14}O_4$	246	1.120^c	1.516^c	166	2.4@150°
249. Dihydrabiethyl phthalate	–	–	–	1.055^c	1.513^c	–	–
250. Butyl cyclohexyl phthalate	$C_6H_4(COOC_4H_9)(COOC_6H_{11})$	$C_{18}H_{24}O_4$	304	1.076	1.5071^c	194	–
251. Butyl benzyl phthalate (BBP)	$C_6H_4(COOC_4H_9)(COOCH_2C_6H_5)$	$C_{19}H_{20}O_4$	312	1.111-1.119	1.5336-1.5376	199	0.1@140°
252. Dicyclohexyl phthalate	$C_6H_4(COOC_6H_{11})_2$	$C_{20}H_{26}O_4$	330	1.148^c	–	207	<0.06@150°
253. Di(methylcyclohexyl) phthalate	$CH_3C_6H_{10}OCOC_6H_4COOC_6H_{10}CH_3$	$C_{22}H_{30}O_4$	358	1.075	1.516	199	0.76@200°
254. Diphenyl phthalate	$C_6H_4(COOC_6H_5)_2$	$C_{20}H_{14}O_4$	318	1.28	1.572@74°	224	–
255. Alkyl aryl phthalate	$R_1OOCC_6H_4COOR_2$	–	<500	$1.052\text{-}1.056^c$	1.517^c	236	–
256. Alkyl aryl phthalate	$R_1OOCC_6H_4COOR_2$	–	–	1.033^c	1.5112^c	243	–
257. Dimethoxyethyl phthalate	$C_6H_4(COOC_2H_4OCH_3)_2$	$C_{14}H_{18}O_6$	282	1.171^c	1.500	193	<0.01@20° 0.25@150°
258. Diethoxyethyl phthalate	$C_6H_4(COOC_2H_4OC_2H_5)_2$	$C_{16}H_{22}O_6$	310	1.120^c	1.491	186	<0.01@20° 0.20@150°
259. Dibutoxyethyl phthalate	$C_6H_4(COOC_2H_4OC_4H_9)_2$	$C_{20}H_{30}O_6$	366	1.063	1.483	208	<0.01@20° 0.06@150°
260. Bis-(diethylene glycol monoethyl ether) phthalate	$C_6H_4(COOCH_2CH_2OCH_2CH_2OC_2H_5)_2$	$C_{20}H_{30}O_8$	398	1.12-1.14	1.492	232	<0.10@150°
261. Glycerol phthalate	–	–	–	1.04	1.5029	207	–
262. Methycyclohexyl isobutyl phthalate	$CH_3C_6H_{10}O(OCC_6H_4CO)OC_4H_9$	$C_{19}H_{26}O_4$	318	1.054	1.5005	–	<0.3mm @145°
263. High molecular weight phthalate	–	–	–	1.0394 @30°	1.4980@30°	216	–

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* Code for column headings: Sp. Gr. = specific gravity; R. I. = refractive index; F. P. = flash point (Cleveland and Open Cup); V. P. = vapor pressure; B. R. = boiling range; M. P. = melting point; S. in water = solubility in water; CA = cellulose acetate; CAB = cellulose acetate butyrate; CN = cellulose nitrate; EC = ethyl cellulose; PM = polymethyl methacrylate; PS = polystyrene; VA = polyvinyl acetate; VB = polyvinyl butyral; VC = vinyl chloride; and VCA = vinyl chloride acetate.

	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS[a]										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS		MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA			
	°C.	°C.	% by wt.													
228.	215-240 @ 4 mm.	<−60	<0.03	P	C	C	C	P	C	P	C	C	C	DCP 715 (62) "Elastex" 80-P (2) "Harflex" 180 (38)	"Monoplex" DCP (63) "Morflex" 120 (52)	2, 4, 38, 40 52, 62, 63
229.	220-230 @4 mm.	−50 to −55	Ins.	I	C	–	C	C	C	–	–	C	C	"Good-rite" GP-261 (35)	"Polycizer" 162 (39)	35, 38, 39, 40
230.	265-320 @ 20 mm.	–	Ins.	P	C	C	I	C	C	P	–	C	C	"Palatinol" F (10)		10
231.	231 @ 5 mm.	−46[f]	<0.01	I	C	C	C	C	C	I	P	C	C	"Celluflex" DOP (17) "Darex" DOP (22) Dioctyl phthalate, DOP DOP 745 (62) "Elastex" 28-P (2) "Flexol" DOP (72) "Griffin" DOP (36) "Harflex" 150 (38)	"Kolflex" (49) "Morflex" 110 (52) "Palatinol" AH (10) "PX"-138 (61) "RC" DOP (64) "Staflex" DOP (21) "Witcizer" 312 (74)	2, 10, 17, 18, 21, 22, 28, 36, 38, 40, 49, 50, 51, 52, 53, 61, 62, 64, 66, 72, 74
232.	216 @ 5 mm.	−53[f]	<0.01	I	I	C	C	I	C	C	C	C	C	"Flexol" CC-55 (72)		72
233.	413	–	Ins.	–	–	–	–	–	C	–	–	C	C	"Morflex" 190 (52) "Palatinol" DN (10)	"Staflex" DNP (21)	10, 21, 40, 52
234.	241 @5 mm.	–	Ins.	I	C	C	C	C	C	I	C	C	C	DNODP (50) "Elastex" 82-P (2) "Hercoflex" 150 (41) "Morflex" 125 (42)	"NODP" 720 (62) "PX"-314 (61) "RC" N-ODP (64) "Staflex" 500 (21)	2, 21, 40, 41, 49, 50, 52, 61, 62, 64
235.	235-248 @4 mm.	−40	Ins.	P	C	C	C	P	C	P	C	C	C	"Darex" IOIDP (S) (22) "Dinopol" IDO (18) "Dinopol" 235 (18) "Elastex" 18-P (2) "Good-rite" GP-265 (35) "Harflex" IODP (38) "Kolflex" (49)	"Morflex" 175 (52) ODP 740 (62) "Polycizer" 562 (39) "PX"-118 (61) "RC" ODP (64) "Staflex" ODP (21) "Witcizer" 321 (74)	2, 13, 18, 21, 22, 38, 39, 40, 51, 52, 53, 61, 62, 64, 74
236.	261 @ 5 mm.	−37[f]	<0.01	P	C	C	C	P	C	P	C	C	C	"Darex" DIDP (22) DDP 725 (62) "Elastex" 90-P (2) "Flexol" 10-10 (72) "Good-rite" GP-266 (35) "Harflex" DIDP (38) "Hercoflex" 210 (41) "Kolflex" (49)	"Morflex" 130 (52) "Palatinol" Z (10) "Plasticizer GC-100" (36) "Polycizer" 662 (39) "PX"-120 (61) "RC" DIDP (64) "Staflex" DDP (21)	2, 10, 13, 18, 21, 22, 35, 36, 38, 39, 40, 41, 49, 50, 51, 52, 53, 61, 62, 64, 72
237.	240 @5 mm.	–	Ins.	I	C	C	C	C	C	I	C	C	C	"Dinopol" MOP (18) "PX" (61)	"Santicizer" 601 (50)	18, 40, 50, 61
238.	–	–	Ins.	–	–	–	–	–	–	–	–	C	C	"Darex" IOIDP (B) (22) "PX" (61)	"Santicizer" 602 (50)	22, 40, 50, 61
239.	245 @5 mm.	–	<0.01	I	C	C	C	P	C	I	P	C	C	"Flexol" 810 (72)	"Staflex" LP (21)	21, 72
240.	224 @5 mm.	–	<0.01	I	C	C	C	P	C	I	P	C	C	"Flexol" 426 (72)		72
241.	–	–	Ins.	I	P	C	C	C	C	C	C	C	C	"Santicizer" 606 (50)		50
242.	–	–	Ins.	I	P	C	C	C	C	C	C	C	C	"Santicizer" 611 (50)		50
243.	–	–	Ins.	I	P	C	C	C	C	C	C	C	C	"Santicizer" 614 (50)		50
244.	240 @5 mm.	–	Ins.	I	C	C	C	C	C	I	C	C	C	"Dinopol" MOP (18) "Hercoflex" 250 (41)	"Palatinol" AG (10)	10, 18, 41
245.	240 @5 mm.	–	Ins.	I	C	C	C	C	C	I	C	C	C	"Pittsburgh PX"-313 (61)		61
246.	215-235 @4 mm.	–	0.01 @25°	C	–	C	C	P	C	C	C	C	C	"Kolflex" 233 (49)	"Ohopex" O-10 (18)	18, 49
247.	241 @5 mm.	–	<0.01	I	C	C	C	P	C	I	C	C	C	"Flexol" 380 (72)		72
248.	156-175 @4 mm.	−70	<0.01	C	C	C	C	–	C	C	C	C	C	–		18
249.	–	65	Ins.	I	–	C	P	I	P	I	P	C	P	"Cellolyn" 21 (41)		41
250.	189-222 @5 mm.	–	<0.005	I	C	C	C	–	C	C	C	C	C	"Elastex" 50-B (2)		2
251.	370 @760 mm.	–	0.0003 @30°	P	C	–	C	–	C	C	C	C	C	"Palatinol" BB (10) "Santicizer" 160 (50)		10, 50
252.	212-218 @5 mm.	58-65	Ins.	P	C	C	P	C	P	C	P	P	P	DCHP 730 (62) "Elastex" DCHP (2)	KP-201 (18)	2, 18, 40, 43, 62
253.	250 @2 mm.	–	Ins.	I	C	C	C	P	C	C	C	C	C	"Sextol" phthalate (43)		43
254.	250-257 @14 mm.	69	Ins.	I	C	C	C	–	C	C	I	C	C	–		50
255.	262-288 @4 mm.	–	Ins.	–	C	C	C	C	C	–	–	C	C	"Staflex" HS-10 (21)		21
256.	283-290 @4 mm.	–	Ins.	–	C	C	C	C	C	–	–	C	C	"Staflex" HS-31 (21)		21
257.	190-210 @4 mm.	–	0.85	C	C	C	C	–	P	C	C	C	C	"Kesscoflex" MCP (48) "Methox" (18)	"Palatinol" O (10)	10, 18, 24, 28, 8
258.	188-215 @4 mm.	31	0.25 @25°	C	C	C	C	–	P	C	C	C	C	–		24, 49
259.	210-233 @4 mm.	–	<0.03 @25°	I	C	C	C	C	C	C	C	C	C	"Kesscoflex" BCP (48) "Kronisol" (18)	"Palatinol" K (10)	10, 18, 24, 48
260.	200-260 @4 mm.	−35	0.8 @25°	C	C	C	C	–	P	C	–	C	C	Di-"Carbitol" phthalate Diethoxyethyl phthalate		18
261.	–	−10	Ins.	–	C	C	C	–	–	P	C	C	C	"Esterflex" B-1 (68)		68
262.	145-165 @2 mm.	–	Ins.	I	C	C	C	C	–	C	C	C	C	–		43
263.	–	–	Ins.	–	–	–	–	–	–	–	–	–	–	"Staflex" KA (20)		20

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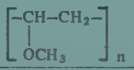
[a] Code for compatibility: C = compatible, P = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers.
[c] Measurement made at 20 °C. [d] The trade marks for plasticizers are shown in quotation marks.
[e] Decomposes at temperatures in this range. [f] Pour point.

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25° C.	R. I. AT 25° C.	F. P.	V. P.
						°C.	*mm. Hg*
264. High molecular weight phthalate	–	–	630	1.05	1.448	–	–
Polyesters							
265. Polyester	–	–	–	1.11	1.467	268	–
266. Polyester	–	–	4000	1.15	1.4719	–	–
267. Polyester	–	–	1500	1.107	1.4803	–	–
268. Polyester	–	–	–	1.055^c	1.4685^c	288	–
269. Polyester	–	–	–	0.9517	1.4521^c	200	–
270. Polyester	–	–	850	1.075^c	1.463-1.464	277	–
271. Polyester	–	–	850	1.031^c	1.4589	260	–
272. Polyester	–	–	8000	1.06	1.470	13	–
273. Polyester	–	–	6000	1.15	1.471	8-78	–
274. Polyester	–	–	6000	1.132	1.469	–25	–
275. Polyester	–	–	2200	1.08	1.466	10	–
276. Polyester	–	–	3380	1.10	1.467	10	–
277. Polyester	–	–	3380	1.084	–	40	–
278. Polyester	–	–	ca. 1000	1.00	1.47	315	–
279. Polyester	–	–	8000	1.06	1.4699	316	–
280. Polyester	–	–	6000	1.15	1.4710	292	–
281. Polyester	–	–	2200	1.08	1.4660	272	–
282. Polyester	–	–	–	–	–	279	–
283. Polyester	–	–	–	1.03	1.460	246	–
284. Polyester	–	–	–	1.22	–	246	–
285. Polyester	–	–	–	0.9213	–	225	–
286. Polyester	–	–	–	0.9200	1.4485	218	–
287. Polyester	–	–	–	0.9550	1.4830	230	–
288. Polyester	–	–	–	0.9565	–	218	–
289. Polyester	–	–	ca. 3000	1.090	–	–	–
290. Polyester	–	–	2500	1.10^c	1.4684	290	–
291. Polyester	–	–	–	1.084	1.465	–	–
292. Polyester	–	–	–	1.050	1.504	–	–
293. Polyester	–	–	–	1.084	–	–	–
Polyvinyl ethers							
294. Polyvinyl-methylether	 $\left[\begin{array}{l}-CH-CH_2-\\ \quad\vert\\ \quad OCH_3\end{array}\right]_n$	$(C_3H_6O)_n$	–	1.04	1.469	–	–
295. Polymeric plasticizer	Derived from neopentyl glycol	–	1200-1300	1.060^c	1.4656^c	279	–
296. Polyester	–	–	–	1.09	1.466	296	–
297. Polyester	–	–	–	1.10	1.4658	293	–
298. Polyester	–	–	–	1.061	1.4676	307	–
Ricinoleic acid derivatives							
299. Methyl ricinoleate	$C_{17}H_{32}(OH)COOCH_3$	$C_{19}H_{36}O_3$	312	0.925	1.4620	190	–
300. Methyl acetyl ricinoleate	$C_{17}H_{32}(OCOCH_3)COOCH_3$	$C_{21}H_{38}O_4$	355	0.938	1.4545	196	–
301. Methyl acetyl ricinoleate (modified)	–	–	–	0.958	1.4580	207	–
302. Butyl ricinoleate	$C_{17}H_{32}(OH)COOC_4H_9$	$C_{22}H_{42}O_3$	355	0.917	1.4620	207	–
303. *n*-Butyl acetyl ricinoleate	$C_{17}H_{32}(OCOCH_3)COOC_4H_9$	$C_{24}H_{44}O_4$	397	0.928	1.4555	210	–
304. Ethylene glycol ricinoleate	$C_{17}H_{32}(OH)COOCH_2CH_2OH$	$C_{20}H_{38}O_4$	342	0.969	1.4740	241	–
305. Propylene glycol ricinoleate	$C_{17}H_{32}(OH)COOCH_2CHOHCH_3$	$C_{21}H_{40}O_4$	357	0.960	1.4695	221	–
306. Methoxyethyl ricinoleate	$C_{17}H_{32}(OH)COOCH_2CH_2OCH_3$	$C_{21}H_{40}O_4$	357	0.951	1.4645	207	–
307. Methoxyethyl acetyl ricinoleate ricinoleate	$C_{17}H_{32}(OCOCH_3)COOCH_2CH_2OCH_3$	$C_{23}H_{42}O_5$	399	0.960	1.4570	215	<0.04 @ 150°
308. Methoxyethyl acetyl ricinoleate (modified)	–	–	–	0.968	1.4630	238	–
309. Glycerol monoricinoleate	$C_{17}H_{32}(OH)COOCH_2CHOHCH_2OH$	$C_{21}H_{40}O_5$	372	0.981	1.4770	265	–
310. Diethylene glycol monoricinoleate	$C_{17}H_{32}(OH)COO(CH_2CH_2O)_2H$	$C_{22}H_{42}O_5$	387	0.972-0.980	–	–	–
311. Glyceryl triacetyl ricinoleate	$[C_{17}H_{32}(OCOCH_3)COO]_3C_3H_5$	$C_{63}H_{110}O_{12}$	1060	0.965	1.4685	290	–
Sebacic acid derivatives							
312. Dimethyl sebacate	$CH_3OCO(CH_2)_8COOCH_3$	$C_{12}H_{22}O_4$	230	0.990	–	–	–
313. Diethyl sebacate	$C_2H_5OCO(CH_2)_8COOC_2H_5$	$C_{14}H_{26}O_4$	258	1.048	1.419	–	–
314. Dibutyl sebacate	$C_4H_9OCO(CH_2)_8COOC_4H_9$	$C_{18}H_{34}O_4$	314	0.935-0.942^c	1.4423^c	180	–
315. Dioctyl sebacate	$C_8H_{17}OCO(CH_2)_8COOC_8H_{17}$	$C_{26}H_{50}O_4$	427	0.913	1.449	215	–

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* Code for column headings: Sp. Gr. = specific gravity; R. I. = refractive index; F. P. = flash point (Cleveland and Open Cup); V. P. = vapor pressure; B. R. = boiling range; M. P. = melting point; S. in water = solubility in water; CA = cellulose acetate; CAB = cellulose acetate butyrate; CN = cellulose nitrate; EC = ethyl cellulose; PM = polymethyl methacrylate; PS = polystyrene; VA = polyvinyl acetate; VB = polyvinyl butyral; VC = vinyl chloride; and VCA = vinyl chloride acetate.

	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS[a]										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS	MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA		
	°C.	°C.	% by wt.												
264.	–	–	0.12	–	C	C	–	–	–	P	C	C	C	"Staflex" KD (19)	19
265.	–	–	–	I	C	C	I	–	–	P	–	C	C	"Admex" 770 (6)	6
266.	–	–	Ins.	I	C	C	I	I	C	P	I	C	C	"Admex" 760 (6)	6
267.	–	–	Ins.	I	C	C	I	–	–	P	–	C	C	"Admex" 761 (6)	6
268.	–	5[f]	<0.01	I	I	C	I	I	–	I	I	C	C	"Flexol" R-2H (72)	72
269.	–	–	Ins.	–	–	–	–	–	–	–	–	C	C	DP-100 (26)	26
270.	–	<–25	Ins.	C	C	C	C	C	C	C	P	C	C	"Plastolein" 9715 (29)	29
271.	–	<–25	Ins.	C	P	C	C	C	C	P	P	C	C	"Plastolein" 9720 (29)	29
272.	–	–	–	I	I	C	I	–	–	I	I	C	–	"Paraplex" G-25 (63)	63
273.	–	–	–	I	C	C	I	–	–	C	I	C	–	"Paraplex" G-40 (63)	63
274.	–	–	–	I	C	C	I	–	–	C	I	C	–	"Paraplex" G-41 (63)	63
275.	–	–	–	I	C	C	I	–	–	C	C	C	–	"Paraplex" G-50 (63)	63
276.	–	–	–	I	C	C	I	–	–	C	I	C	–	"Paraplex" G-53 (63)	63
277.	–	–	–	I	C	C	I	–	–	C	I	C	–	"Paraplex" G-54 (63)	63
278.	–	0	Ins.	–	–	C	C	–	–	–	–	C	C	"Plastolein" 9232 (29)	29
279.	–	13-15	0.004	I	I	C	I	I	I	P	I	C	C	"Elastex" 37R (2), "Paraplex" G-25 (63)	2, 63
280.	–	<–78	Ins.	I	C	C	I	I	I	C	I	C	I	"Paraplex" G-40 (63)	63
281.	–	10	Ins.	I	C	C	I	I	I	C	P	C	C	"Paraplex" G-50 (63)	63
282.	–	10	Ins.	I	C	C	I	I	I	P	I	C	C	ABG (10), "Paraplex" G-53 (63) "Elastex" 36R (2) "Plastigen" K (10)	2, 10, 63
283.	–	–10	Ins.	–	C	C	C	C	–	–	P	C	C	DP-250 (26), "Monoplex" S-73 (63)	26, 39, 63
284.	197 @ 4 mm.	–	–	C	C	C	I	–	–	C	I	P	P	"Hercoflex" 900 (41)	41
285.	–	0	Ins.	P	P	C	C	–	–	C	–	C	C	"Morflex" P-10A (52)	52
286.	–	–21	Ins.	P	P	C	P	–	–	C	–	C	C	"Morflex" P-20B (52)	52
287.	–	–51	Ins.	P	P	C	P	–	–	C	–	C	C	"Morflex" P-30A (52)	52
288.	–	–37	Ins.	P	P	C	P	–	–	C	–	C	C	"Morflex" P-40B (52)	52
289.	–	–	Ins.	–	–	–	–	–	–	C	–	C	C	"Morflex" P-50 (52)	52
290.	–	–10	Ins.	I	C	C	I	I	C	P	I	C	C	"RC" BGA (64)	64
291.	–	–	Ins.	–	C	C	I	–	–	C	–	C	C	"Admex" 562 (6)	6
292.	–	–	Ins.	P	C	C	C	–	–	P	C	C	C	"Drapex" 7.7 (7)	7
293.	–	4	Ins.	I	C	C	I	I	I	P	I	C	C	"Paraplex" G-54 (63)	63
294.	–	–	Sol.	I	I	C	I	I	C	I	–	I	I	"Lutonal" M40 (10)	10
295.	–	–	Ins.	C	C	P	P	–	–	C	–	C	C	"Eastman" NP-10 (28), "Harflex" 300, 325, and 375 (38)	28,38
296.	–	–	–	I	C	C	C	C	I	P	–	C	C	"Harflex" 300 (38)	38
297.	–	–	–	I	C	C	C	C	I	C	–	C	C	"Harflex" 325 (38)	38
298.	–	–	–	I	I	C	I	I	I	P	I	C	C	"Harflex" 375 (38)	38
299.	170 @ 1 mm.	–30 (pour pt.)	Ins.	P	C	C	C	P	–	C	C	I	I	"Flexricin" P-1 (11); "Nopco" 1060-C (56)	11, 56
300.	185 @ 1 mm.	<–30	Ins.	P	C	C	C	P	P	C	C	C	C	"Flexricin" P-4 (11)	11
301.	–	–40	Ins.	I	C	C	C	–	–	C	C	C	C	"Flexricin" 61 (11)	11
302.	185 @ 1 mm.	–30	Ins.	I	C	C	C	–	P	C	C	I	C	"Flexricin" P-3 (11), "Staflex" BR (21)	11, 21, 48
303.	195 @ 1 mm.	–32 to –65	Ins.	I	C	C	C	P	P	C	C	C	C	"Flexricin" P-6 (11), "Staflex" BRA (21)	11, 21
304.	–	–21	Ins.	–	–	C	C	–	–	–	C	I	–	"Flexricin" 15 (11)	11
305.	–	<–16	Ins.	–	–	C	C	–	–	–	–	–	–	"Flexricin" 9 (11)	11, 48
306.	185 @ 1 mm.	–37	Ins.	I	C	C	C	–	P	C	C	C	C	"Flexricin" P-1C (11)	11, 34
307.	195 @ 1 mm.	–60	Ins.	I	C	C	C	–	P	C	C	C	C	"Flexricin" P-4C (11) KP-120 (18), "Staflex" IXA (21)	11, 18, 21
308.	–	–46	Ins.	I	C	C	C	–	–	C	C	C	C	"Flexricin" 62 (11)	11
309.	–	<–50	Ins.	–	–	C	C	–	–	–	C	–	–	"Flexricin" 13 (11), "Nopco" 2225-C (56)	1, 11, 34, 48, 56
310.	–	<–60	Ins.	–	–	C	C	–	–	–	–	–	–	–	34, 48
311.	–	–35 (pour pt.)	Ins.	I	I	C	C	–	P	C	–	C	C	"Flexricin" P-8 (11)	11
312.	294	–	V. sl. sol.	C	C	C	C	C	C	C	C	C	C	"Harflex" 10 (38)	38, 40
313.	308	1.3	0.190	I	C	–	–	–	–	–	–	–	–	–	24, 38, 40
314.	344-345 175-180 @ 3 mm.	–11	<0.01	I	C	C	C	C	C	C	C	C	C	DBS 755 (62) "Griffin" DBS (36) "Harflex" 40 (38) "Monoplex" DBS (63) "Morflex" 240 (52) "Polycizer" DBS (39) "PX"-404 (61) "Staflex" DBS (21)	2, 21, 28, 36, 38, 39, 40, 52, 53, 61, 62, 63
315.	248 @ 4 mm.	–55	Ins.	I	P	C	C	C	C	P	P	C	C	"Darex DOS (22) DOS 765 (62) "Griffin" DOS (36) "Harflex" 50 (38) "Monoplex" DOS (63) "Morflex" 210 (52) "Polycizer" DOS (39) "PX"-438 (61) "RC" DOS (64) "Staflex" DOS (21)	21, 22, 36, 38, 40, 52, 53, 61, 62, 63, 64

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[a] Code for compatibility: C = compatible, P = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers.
[c] Measurement made at 20°C. [d] The trade marks for plasticizers are shown in quotation marks.
[e] Decomposes at temperatures in this range. [f] Pour point.

NAME*	STRUCTURAL FORMULA	EMPIRICAL FORMULA	MOLECULAR WEIGHT	SP. GR. AT 25° C.	R. I. AT 25° C.	F. P.	V. P.
						°C.	*mm. Hg*
316. Di-isooctyl sebacate	$C_8H_{17}OCO(CH_2)_8COOC_8H_{17}$	$C_{26}H_{50}O_4$	427	0.9160^{c}	1.4480	246	–
317. Di-iso-octyl isosebacate	$C_8H_{16}(COOC_8H_{17})_2$	$C_{26}H_{50}O_2$	426	0.916	1.4476	215	–
318. Di-2-ethylhexyl isosebacate	$C_8H_{16}(COOC_8H_{17})_2$	$C_{18}H_{34}O_4$	426	0.910 @ 77° F.	1.447-1.4482 @ 77° F.	214-232	–
319. Di-normal-butyl isosebacate	$C_8H_{16}(COOC_4H_9)_2$	$C_{26}H_{50}O_4$	314	0.930-0.931 @ 77° F.	1.4377 @ 77° F.	177	–
320. Dibutoxyethyl sebacate	$(CH_2)_8(COOC_2H_4OC_4H_9)_2$	$C_{22}H_{42}O_6$	403	0.964-0.970	1.4447	–	–
321. Butyl benzyl sebacate	$(CH_2)_8(COOC_4H_9)(COOCH_2C_6H_5)$	$C_{21}H_{32}O_4$	348	1.023	–	–	–
322. Dibenzyl sebacate	$(CH_2)_8(COOCH_2C_6H_5)_2$	$C_{24}H_{30}O_4$	382	1.05	1.521^{c}	236	–
323. Mixed sebacate adipate ester	–	–	411	0.93	1.445	–	–
Stearic acid derivatives							
324. *n*-Butyl stearate	$C_{17}H_{35}COOC_4H_9$	$C_{22}H_{44}O_2$	341	0.855-0.862	1.4418	188	–
325. Octyl stearate	$C_{17}H_{35}COOC_8H_{17}$	$C_{26}H_{52}O_2$	397	0.851-0.857	–	–	–
326. Cyclohexyl stearate	$C_{17}H_{35}COOC_5H_{11}$	$C_{24}H_{46}O_2$	367	0.880-0.883 @ 30°	–	–	–
327. 1, 2-Propylene glycol monostearate	$C_{17}H_{35}COOCH_2CHOHCH_3$	$C_{21}H_{42}O_3$	343	0.93	–	–	–
328. Ethylene glycol monomethyl ether stearate	$C_{17}H_{35}COOCH_2CH_2OCH_3$	$C_{21}H_{42}O_3$	343	0.885	–	–	–
329. Ethylene glycol monobutyl ether stearate	$C_{17}H_{35}COOC_2H_4OC_4H_9$	$C_{24}H_{48}O_3$	385	0.877-0.882^{c}	1.446	216	<0.01 @ 20° 0.06 @ 150°
330. Glycerol monostearate	$C_{17}H_{35}COOCH_2CHOHCH_2OH$	$C_{21}H_{42}O_4$	359	0.970	–	–	–
331. Glyceryl tri-acetoxy stearate	$[C_{17}H_{34}(OCOCH_3)COO]_3C_3H_5$	$C_{63}H_{116}O_{12}$	1066	0.955	1.4595	300	–
332. Butyl acetoxystearate	$C_{17}H_{34}(OCOCH_3)COOC_4H_9$	$C_{24}H_{46}O_4$	398	0.922	1.4480	207	–
333. Diethylene glycol distearate	$(C_{17}H_{35}COOC_2H_4)_2O$	$C_{40}H_{78}O_5$	639	0.96	–	–	–
334. Tetraethylene glycol monostearate	$C_{17}H_{35}COO(CH_2CH_2O)_4H$	$C_{26}H_{52}O_6$	461	0.971	–	–	–
335. Tetraethylene glycol distearate	$(C_{17}H_{35}COOCH_2CH_2OCH_2CH_2)_2O$	$C_{44}H_{86}O_7$	727	–	–	–	–
336. Methyl pentachlorostearate (stabilized)	$Cl_5C_{17}H_{30}COOCH_3$	$C_{19}H_{33}O_2Cl_5$	471	1.19	–	164	0.015 @ 120°
Styrene derivatives							
337. Styrene resin	–	–	ca. 260	1.01 @ 60°	1.5809 @ 60°	165	–
338. Styrene resin	–	–	ca. 310	1.04 @ 60°	1.5728 @ 60°	180	–
339. Styrene resin	–	–	300-20,000	1.04	1.573	149-260	–
340. Styrene derivative	–	–	ca. 250	1.08	1.599	–	–
Succinic acid derivatives							
341. Diethyl succinate	$C_2H_5OCOCH_2CH_2COOC_2H_5$	$C_8H_{14}O_4$	174	1.048	1.419	–	–
342. Dibutyl succinate	$C_4H_9OCOCH_2CH_2COOC_4H_9$	$C_{12}H_{22}O_4$	230	0.974	1.428	–	–
Sucrose derivative							
343. Sucrose octaacetate	$C_{12}H_{14}O_3(OCOCH_3)_8$	$C_{28}H_{38}O_{19}$	679	1.28^{c}	–	307	–
Sulfonic acid derivatives							
344. Benzinesulfonbutylamide	$C_6H_5SO_2NHC_4H_9$	$C_{10}H_{15}O_2NS$	213	1.148	1.525	–	–
345. *o*- and *p*-toluenesulfonamide	$CH_3C_6H_4SO_2NH_2$	$C_7H_9O_2NS$	171	1.313	–	206	–
346. N-Ethyl *p*-toluenesulfonamide	$CH_3C_6H_4SO_2NHC_2H_5$	$C_9H_{13}O_2NS$	199	1.171 @ 65°	1.522 @ 65°	188	–
347. *o*- and *p*-toluene-ethylsulfonamide	$CH_3C_6H_4SO_2NHC_2H_5$	$C_9H_{13}O_2NS$	199	1.188	1.540	174	–
348. N-Cyclohexyl *p*-toluenesulfonamide	$CH_3C_6H_4SO_2NHC_6H_{11}$	$C_{13}H_{19}O_2NS$	253	1.125	–	–	–
349. Urea-formaldehyde-modified	–	–	–	1.07	1.477	–	–
Tall oil derivative							
350. Methyl ester of tall oil	–	–	310	0.96^{c}	1.495^{c}	178	–
Tartaric acid derivatives							
351. Diethyl tartrate	$C_2H_5OCO(CHOH)_2COOC_2H_5$	$C_8H_{14}O_6$	206	1.19	1.445	–	–
352. Dibutyl tartrate	$C_4H_9OCO(CHOH)_2COOC_4H_9$	$C_{12}H_{22}O_6$	262	1.093	1.447	170	–

*Code for column headings: Sp. Gr. = specific gravity; R. I. = refractive index; F. P. = flash point (Cleveland and Open Cup); V. P. = vapor pressure; B. R. = boiling range; M. P. = melting point; S. in water = solubility in water; CA = cellulose acetate; CAB = cellulose acetate butyrate; CN = cellulose nitrate; EC = ethyl cellulose; PM = polymethyl methacrylate; PS = polystyrene; VA = polyvinyl acetate; VB = polyvinyl butyral; VC = vinyl chloride; and VCA = vinyl chloride acetate.

	B. R.	M. P.	S. IN WATER	COMPATIBILITY WITH PLASTICS[a]										COMMON NAMES, TRADE DESIGNATIONS, AND TRADE MARKS[d] FOR PLASTICIZERS	MANUFACTURERS[b]
				CA	CAB	CN	EC	PM	PS	VA	VB	VC	VCA		
	°C.	°C.	% by wt.												
316.	232-246 @4 mm.	–50	Ins.	I	P	–	C	C	C	P	P	C	C	"Griffin" (36) "Hallco" C-545 (37) "Harflex" DIOS (38) "Morflex" 200 (52) "PX" 408 (61) "RC" DIOS (64) "Staflex" DIOS (21)	21, 36, 37, 38, 40, 52, 61, 64, 74
317.	242-253 @ 5 mm.	–45	Ins.	I	P	C	C	C	C	P	P	C	C	"RC" DIOIS (64)	64
318.	222-240 @ 4 mm.	–	Ins.	I	P	C	C	C	C	P	P	C	C	"Hallco" C-574 (37) "Kesscoflex" DIOS (48)	37, 48, 56
319.	170-184 @ 4 mm.	–	Ins.	I	C	C	C	C	C	P	P	C	C	"Hallco" C-574 (37) "Kesscoflex" DIOS (48)	37, 48, 72
320.	255 @ 10 mm.	–10	Ins.	–	–	–	–	–	–	–	–	C	C	"Staflex" DBES (21)	21
321.	245-285 @ 10 mm.	–	Ins.	–	C	C	–	C	–	C	C	C	C	"Morflex" 245 (52)	38, 52
322.	265 @ 4 mm.	28	0.001	P	P	C	C	C	C	C	C	P	P	"Harflex" 90 (38) "Morflex" 250 (52)	38, 52
323.	–	–	Ins.	–	–	–	–	–	–	–	–	C	C	"Staflex" LA (21)	21
324.	220-225 @25 mm.	16	0.2 @25°	I	C	C	C	–	C	–	–	–	I	"Harflex" BS (38) "Kesscoflex" BS (48) "Kolflex" 308 (49) "Morflex" BS (52) "RC" B-17 (64) "Staflex" BS (21) "Witcizer" 200-201 (74)	9, 10, 18, 19, 21, 26, 38, 48, 49, 52, 56, 64, 68, 74
325.	–	1-6	Ins.	–	–	–	–	–	–	–	–	–	–	"Kesscoflex" OS (48)	48
326.	–	28-29	Ins.	I	I	C	C	–	C	–	–	–	I	–	43, 48
327.	182-210 @1 mm.	37-39	Ins.	–	–	C	–	–	–	–	–	–	–	–	1, 30, 34, 48
328.	220-275 @20 mm.	20-24	Ins.	–	C	C	C	–	–	–	–	–	–	"Kesscoflex" MCS (48) Methoxyethyl stearate	48
329.	215-250 @4 mm.	15-17	Ins.	I	P	C	C	I	C	P	C	P	P	Butoxyethyl stearate KP-23 (18) "Kesscoflex" BCS (48)	18, 48
330.	–	55-57	Ins.	–	–	–	–	–	–	–	–	–	–	"Morpel" X-710 (52) "Nopco" 2225-P (56)	1, 26, 30, 34, 38, 48, 52, 56, 68, 74
331.	–	–	Ins.	P	C	C	C	–	P	C	C	C	C	"Paricin" 8 (11)	11
332.	–	–7	Ins.	P	C	C	C	–	P	C	C	C	C	"Paricin" 6 (11)	11
333.	–	48	Ins.	–	–	C	C	–	–	–	–	–	–	"Morpel" X-932 (52) "Nopalcol" I-S (56)	1, 48, 52, 56
334.	–	35-40	Ins.	–	–	C	C	–	–	–	–	–	–	–	48
335.	–	32-33	Ins.	–	–	–	–	–	–	–	–	–	–	–	48
336.	–	–39	Ins.	C	C	C	C	C	C	C	I	C	C	"MPS"-500 (42)	42
337.	150-300 @5 mm.	–	Ins.	I	C	P	C	P	C	P	C	P	P	Dow resin 276-V2 (25)	25
338.	150-300 @5 mm.	–	Ins.	I	C	P	C	P	C	P	C	P	P	Dow resin 276-V9 (25)	25
339.	–	5-140	Ins.	P	P	P	P	P	C	P	I	I	I	"Percolastic" (62)	62
340.	> 300	–15	Ins.	C	C	C	C	C	C	C	C	C	C	"Nevillac" TS (54)	54
341.	218	–22	0.190	C	C	C	–	–	–	–	–	–	–	–	24, 55
342.	255	–19	0.023	C	C	C	–	–	–	–	–	–	–	–	24, 55
343.	260 @0.01 mm.	89	0.09	C	–	C	C	–	–	C	–	–	–	SOA (72)	72
344.	205-220 @ 10 mm.	–	Ins.	C	C	C	C	P	I	C	–	I	P	"Plastomoll" BMB (10)	10
345.	360	105	ca. 1	P	P	P	C	–	I	C	I	I	I	"Santicizer" 9 (50)	50
346.	340	58	0.6 @34°	C	C	–	–	–	–	–	–	–	–	"Santicizer" 3 (50)	50
347.	340	18	0.13 @23°	C	C	C	C	–	C	C	C	I	I	"Santicizer" 8 (50)	50
348.	350	86	–	P	P	C	C	–	P	–	–	–	–	"Santicizer" 1-H (50)	50
349.	–	–	Ins.	I	I	C	C	I	I	I	–	I	I	"Plastigen" G (10)	10
350.	–	–	Ins.	P	–	P	C	–	–	P	C	C	C	"Metalyn" 41	41
351.	280	17	> 50	C	C	–	–	–	–	–	–	–	–	–	24, 46
352.	292-312	20-22	0.485	C	C	C	C	C	–	C	–	–	C	"Kesscoflex" DBT (48), "Witcizer" (74)	24, 48, 74

[a] Code for compatibility: C = compatible, P = partially compatible, I = incompatible. [b] See list on page 576 for key to numbers.
[c] Measurement made at 20 °C. [d] The trade marks for plasticizers are shown in quotation marks.
[e] Decomposes at temperatures in this range.

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1. Advance Solvents and Chemical, Div. of Carlisle Chemical Works, Inc., 500 Jersey Ave., New Brunswick, N.J.
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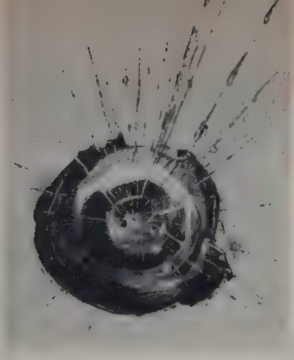

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Ideal Plastics Corp.	774
Industrial Molded Products Co., Inc.	716
Keolyn Plastics, Inc.	714
Kingman, E. B., Co., Inc.	766
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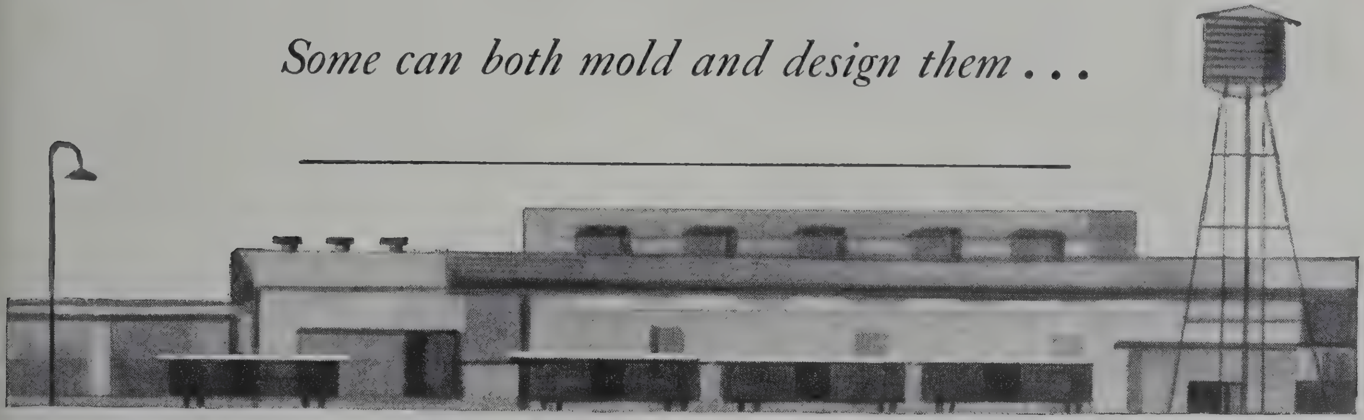

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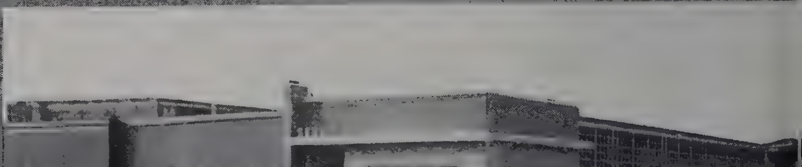

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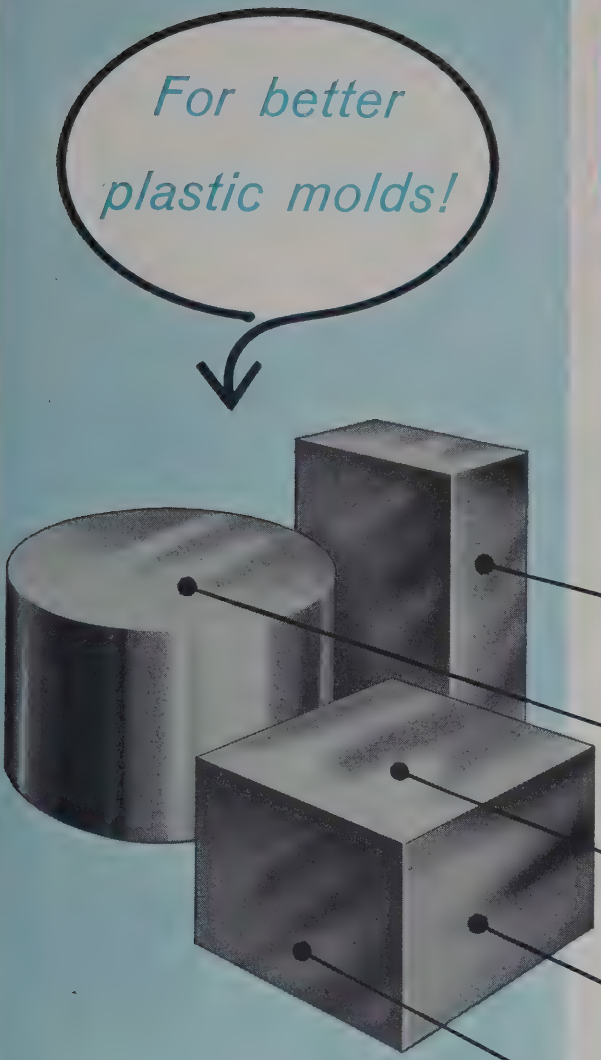
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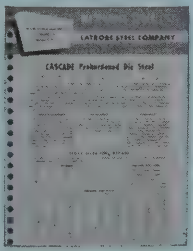
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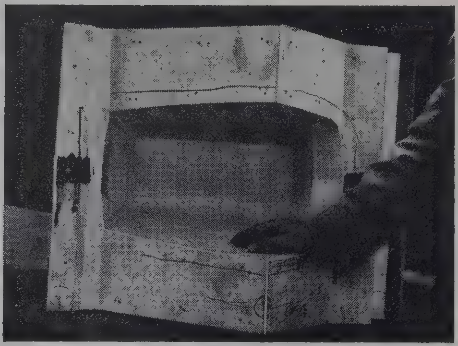
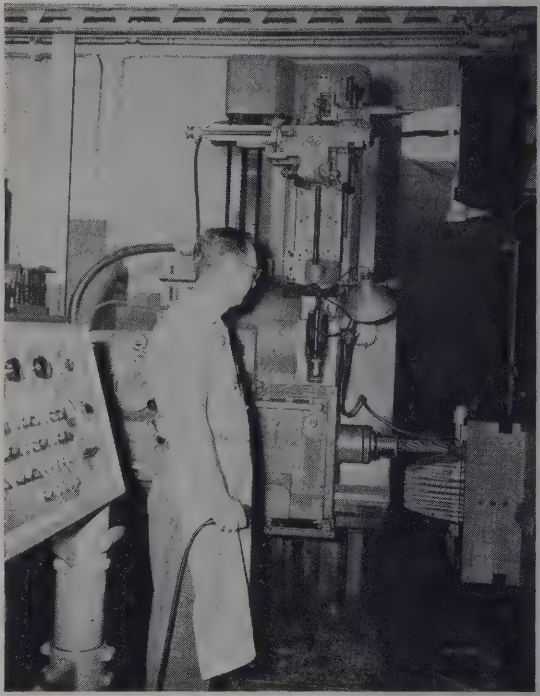
STEP 'B'



Preparing the Keller Model. Shown here is half of a set of precise Keller models (one male, one female) made from the carefully finished wood pattern. Engelking prepares the models by building up over the pattern with a combination of glass cloth and special epoxy resin. When cured, these models act as "copy" for the Keller.

STEP 'C'



Kellering the Mold. The male epoxy-glass model is shown mounted on Engelking's 6′ x 4′ Keller where it is automatically traced and reproduced, contour for contour, in tool steel. A fine hand finishing operation readies it and its mate for molding. In this instance the reinforced plastics product is the housing for a popular outboard motor.

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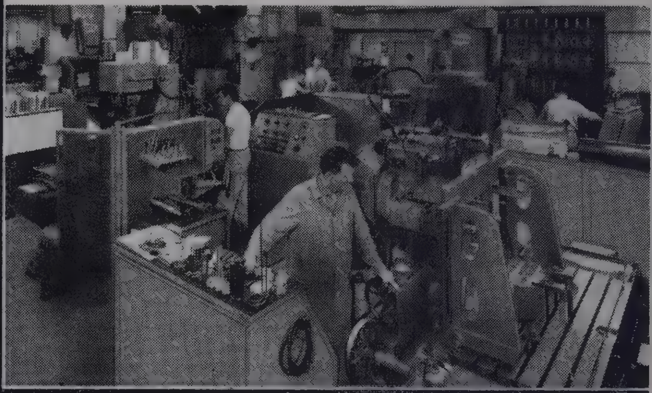

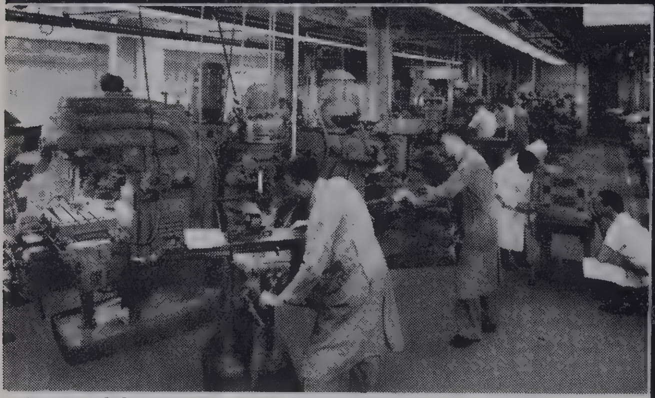

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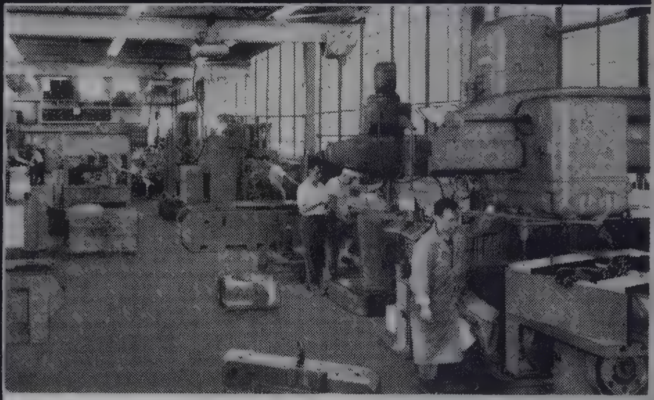

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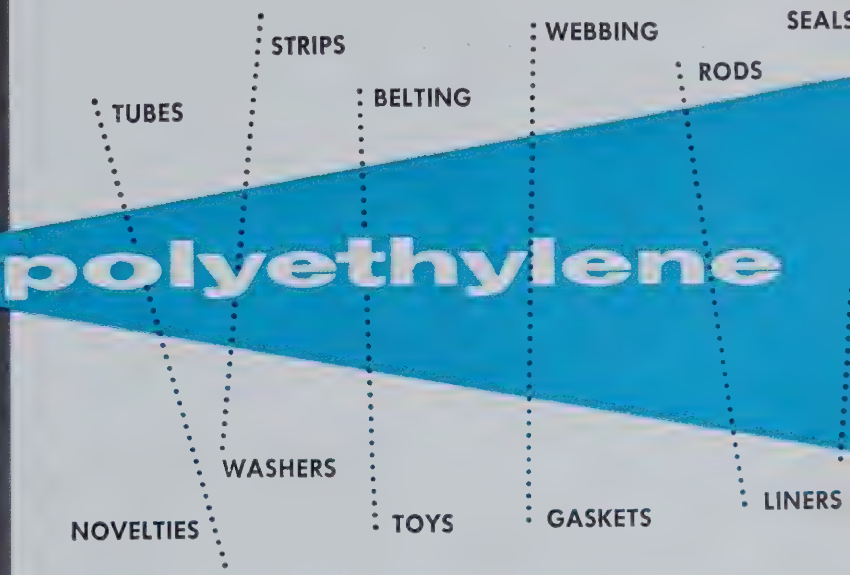

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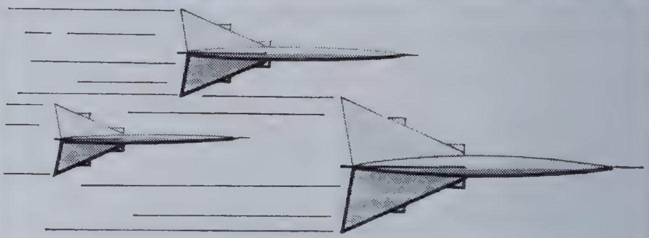

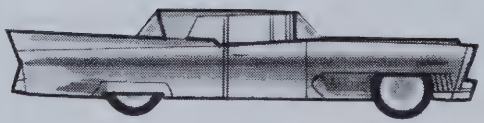

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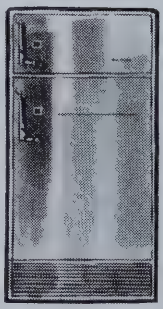

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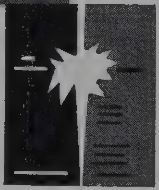

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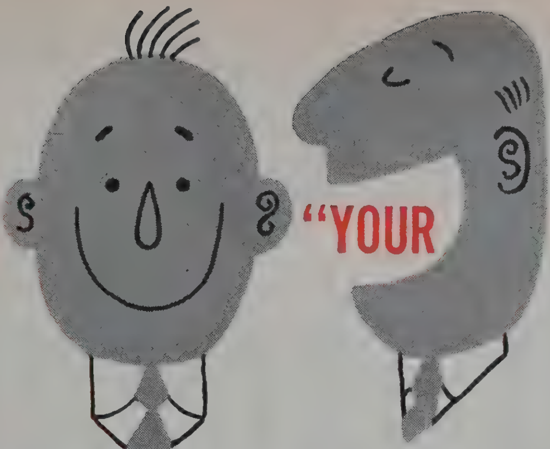

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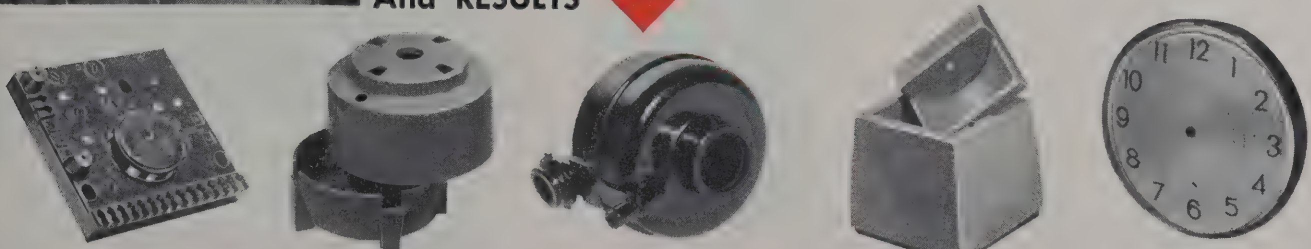

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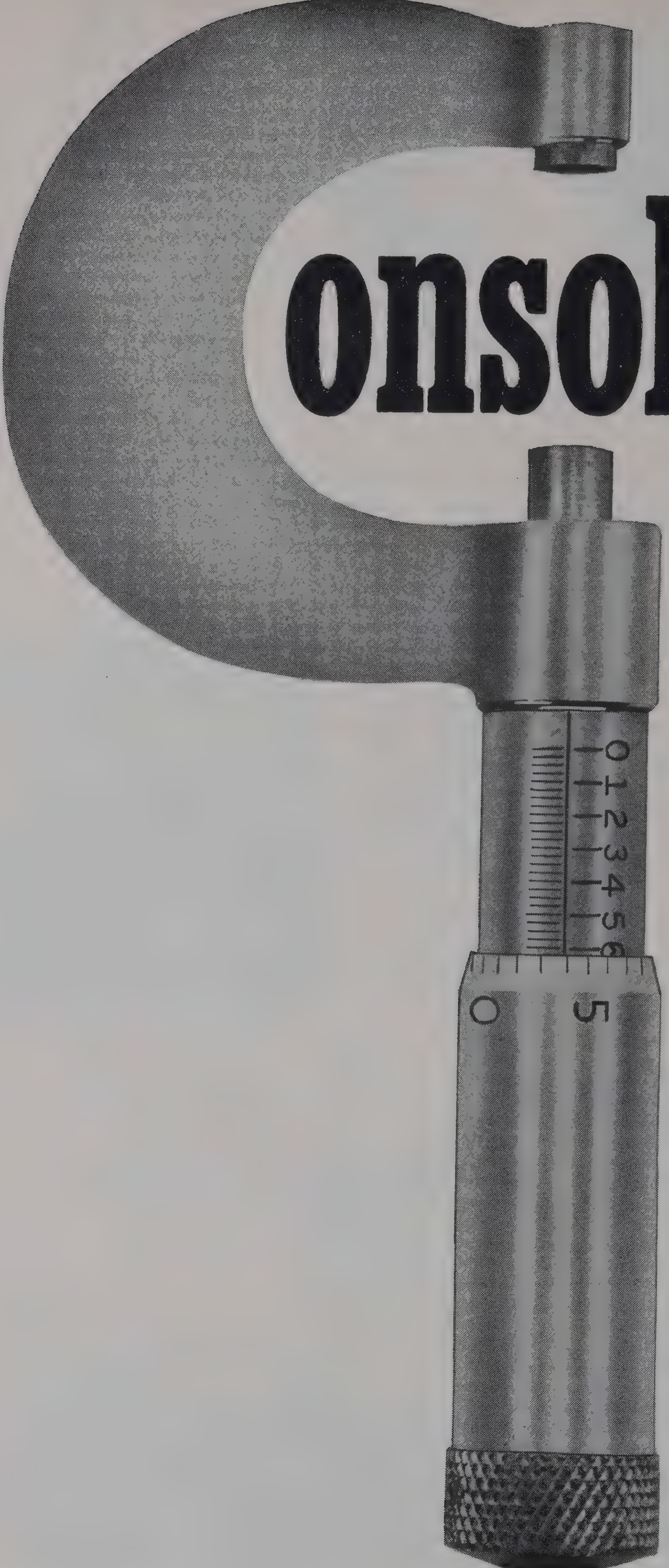

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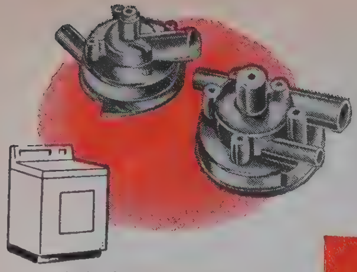
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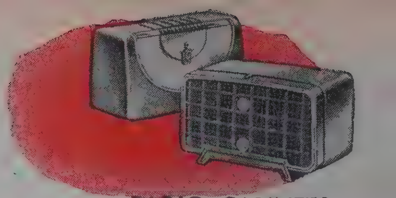
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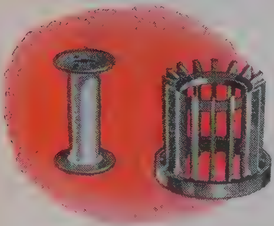
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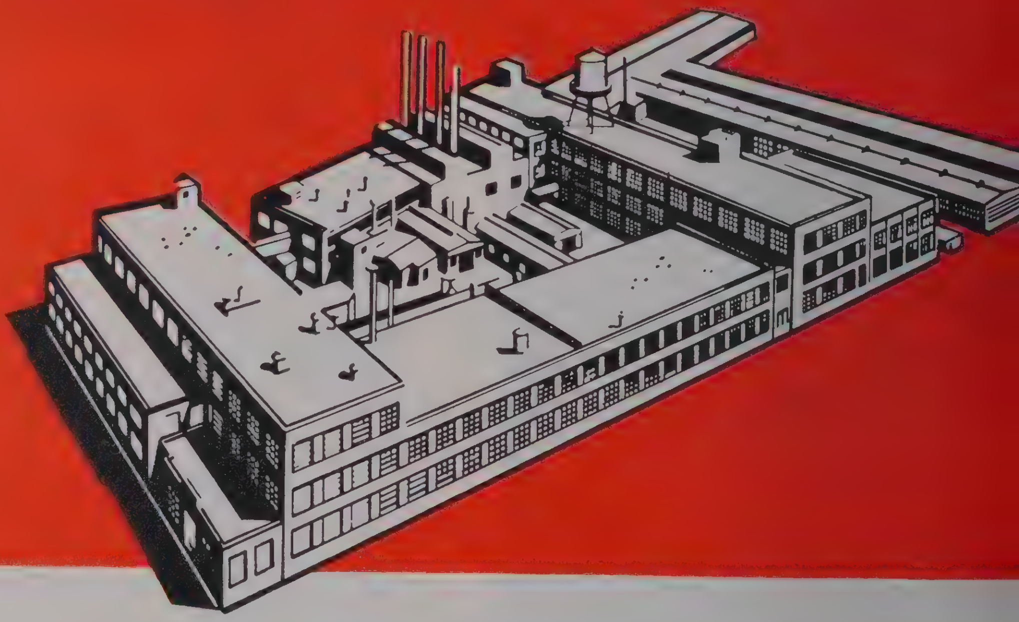

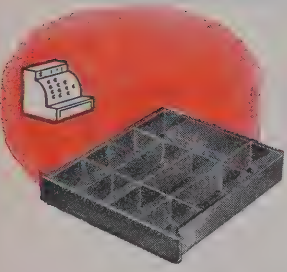
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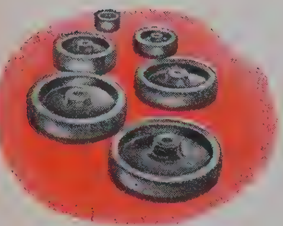
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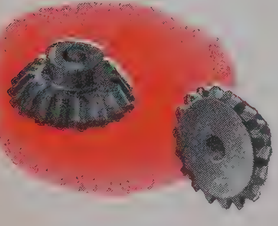
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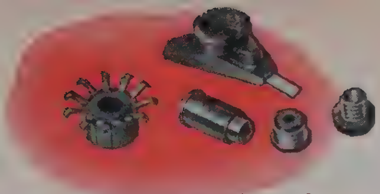

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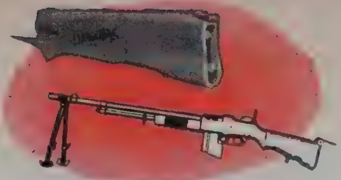

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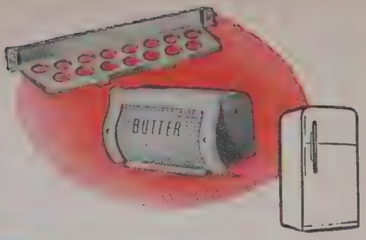

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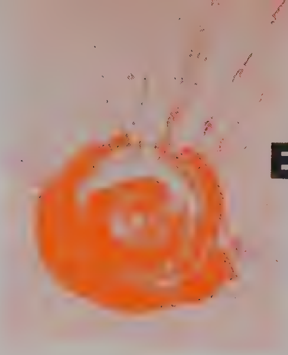

ENGINEERING AND METHODS

Injection molding

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INJECTION MOLDING: Acetal resin

By K. J. Persak*

Molding of Delrin[1] acetal resin has been successfully accomplished in a wide variety of injection machines ranging in capacity from 1 to 60 ounces. Although older machines have produced good parts, newer machines with high ram speeds run on faster cycles and produce pieces of better quality. (For case histories, see Fig. 1, opposite, and Table 1, below.)

Time-temperature

The hold-up time (HUT) of Delrin in the injection cylinder is important in molding good quality parts. HUT equals:

$$\frac{\text{Machine size (oz.)} \times \text{cycle (sec.)}}{\text{Shot weight (oz.)} \times 10}$$

This expression assumes that the weight of the acetal resin in the injection cylinder is six times the nominal ounce capacity of the machine. Fig. 2, (opposite), shows acceptable hold-up times *versus* melt temperature. If hold-up time is excessive at any given temperature, discoloration and evolution of formaldehyde may possibly result.

For correct use of the information in Fig. 2, the actual temperature of the melt must be checked against the temperature shown by the control instruments. This can be done with a needle probe on a hand pyrometer. The melt temperature measurements are made by taking air shots, using the same over-all cycle as when molding.

Melt flow

In understanding the molding characteristics of any resin it is helpful to know the basic relation of melt viscosity to temperature. Fig. 3, p. 596, charts melt viscosity *versus* temperature for several thermoplastics, including Delrin. For example, note that Delrin 500 series resin is comparable to Alathon[1] 14 polyethylene resin, which has a low melt index. But as the slope of the curve for Delrin shows, its viscosity does not vary as much with changes in temperature as some of the other thermoplastics. Increasing the cylinder temperatures, therefore, will be of less value in improving flow. Normally, both 500 and 100 series resins are molded in the range of 400 to 440° F. The upper molding temperature can be approximated by referring to the information on hold-up time (Fig.

TABLE I: Molding data on case histories shown in Fig. 1[1]

Symbol	*Number of cavities*	*Wall thickness*	*Shot weight*	*Machine size*	*Melting rate*
		in.	*oz.*	*oz.*	*lb./hr.*
1	1	0.080	6.5	12	61
2	1	0.060	5.5	16	22
3	1	0.100	10	24	52
4	2	0.100	3	8	28
5	3	0.060	3	8	32
6	4	0.060	2	4	18
7	4	0.125	6	8	15
8	8	0.050	1	4	21
9	12	0.250	6	12	31
10	16	0.080	11	20	115

[1] Runs 1 and 10 were made with Delrin 500 series resin on new, fast injecting machines capable of very fast cycles and high melt rates.

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*Polychemicals Dept., E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.

[1] Du Pont trademark.

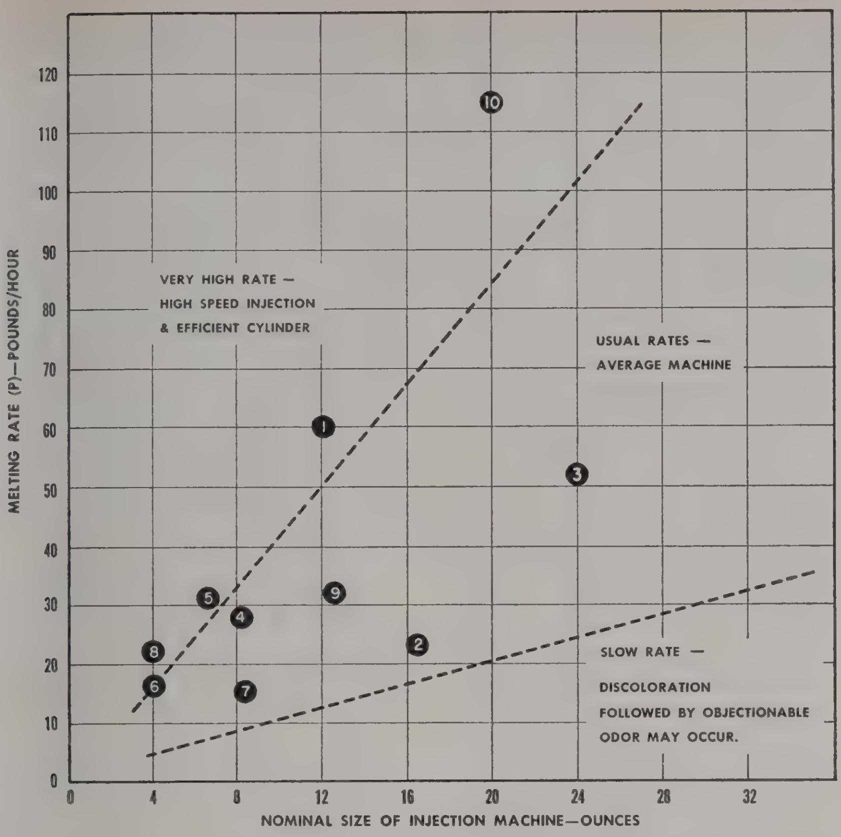

FIG. 1: Melting rate vs machine size. Numbers refer to data presented in Table I, opposite

2), which indicates that increases in cylinder temperature should be made with great care if there is difficulty in filling the mold. Assuming the melt temperature is already about 420 to 440° F., then other changes, such as increasing the mold temperature or increasing the size of gates, may be necessary to increase flow without overheating the resin.

Mold temperature

The importance of using a hot mold to get good dimensional stability is indicated by Table II, p. 596, although in some cases it may be desirable to anneal the molded parts instead.

To get acceptable surface on most industrial parts, a mold temperature in the 140 to 170° F. range is adequate. However, to get the optimum surface on a hard-to-fill part, the mold temperature can be 200 to 250° F.

The "trouble-shooting" tabulation, p. 627, shows where mold temperature can be used to improve the molding operation.

Molder's guide

Since no two thermoplastics are alike, here are some tips to help molders get started on the right foot with acetal resin. These procedures have proved best when molding in a great variety of machines.

1) Starting up with a clean machine:
   a) Start up as you would with most typical thermoplastics.
   b) Set your machine as follows:
      Temperature of melt: about 400° F.
      Temperature of cylinder: 400 to 430° F.
      Pressure: High—from 12,000 p.s.i. to 18,000 p.s.i.
      Ram speed: As fast as possible.
      Cycle: Begin with about 1 min. for each ¼ in. of part thickness.
      Mold temperature: If part requires high gloss or maximum dimensional stability, use a hot mold (200 to 250° F.).
2) Change over from another thermoplastic to acetal resin:
   a) Set cylinder and nozzle heats for material now in ma-

FIG. 2: Limits of hold-up times (HUT) vs melt temperature for injection molding of acetal resin. Satisfactory time-temperatures are indicated by the lighter area in upper right corner; as the density of the gray tint increases, possibility of overheating and yellow streaking increases

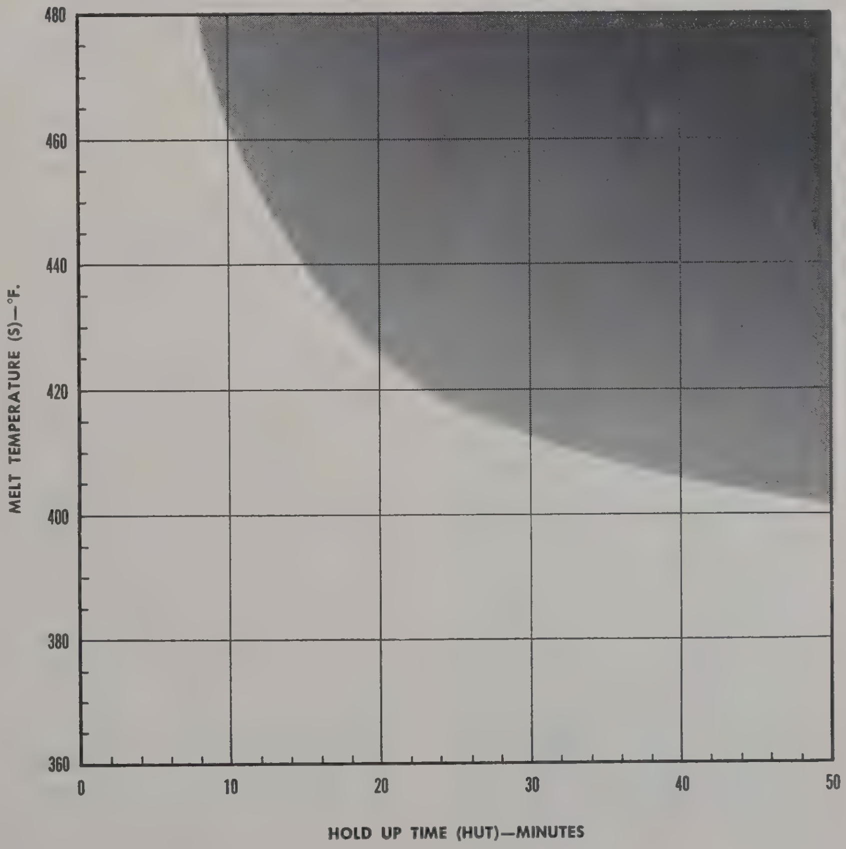

TABLE II: Environmental shrinkage of acetal moldings due to stress relaxation.[1]

Environmental temperature	Shrinkage (mils/in.)
A) *Routine molding—samples annealed at 320° F. for 15 minutes*	
—40 to 170° F.	< 0.5
170 to 212° F.	≤ 1.5
212 to 248° F.	≤ 2.5
B) *Molded—hot mold (250° F.)—no annealing treatment*	
—40 to 170° F.	< 0.5
180° F.	1
200° F.	2.5
212° F.	4
C) *Routine molding—cold mold (100 to 150° F.)—no annealing treatment*	
—40 to 125° F.	≤ 1
125 to 150° F.	≤ 1.5
150 to 175° F.	≤ 3

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[1] Based on measurements of pieces at room temperature after exposures listed. Results were obtained on a variety of parts including the following shapes: dish, gear, sphere, dumbbell tensile bars, fatigue bars, and disks.

chine, and permit the material to melt.

b) To purge old thermoplastic, run three or four air shots of low melt index polyethylene through at maximum injection pressure. Run the polyethylene through so fast it stays cold and hard and keeps the ram from completing its full stroke. The cold resin particles will help scrape the old material from the cylinder walls.

c) Wait a couple of minutes for the plastic to heat up again and then run another group of fairly rapid air shots.

d) Keep repeating steps b) and c) until only polyethylene is coming out. This may take as long as a full hour.

e) Adjust the temperature to 400° F. If this means lowering it, keep running polyethylene through to help cool the cylinder and torpedo.

f) Feed in Delrin. When there's no longer any polyethylene in the melted acetal, you're ready to mold.

g) If it's necessary to stop molding for more than 15 min., shut off the cylinder heat. Then take a few air shots to clear the hot material from the cylinder. This same procedure should be followed when shutting down.

3) Restarting with Delrin in the machine:

a) Raise the temperature slowly to make sure there's no danger of blowing out a cold plug.

b) Set heats at no more than 300° F. on machines larger than 6 ounces. Set smaller machines at no more than 350° F. across the cylinder.

c) Let the machine stay at this setting for an hour's soaking period. Then raise the nozzle heat gradually to 400° F.

d) Bring the cylinder heat to 400° F. Do this by raising the temperature 25 to 50° F. at a time and allowing good soaking periods between the steps. When the acetal gets to 400° F., you'll be able to start moving it.

e) Run a couple of air shots before production to clear out any overheated material. If material doesn't push out easily, look for a cold spot: often there's one where the nozzle threads in. If material is not moving through the cylinder, don't look into hopper without adequate protective covering.

4) Switching from Delrin to another thermoplastic:

a) Leave the temperature at the right setting for acetal.

b) Purge with air shots of polyethylene until all of the acetal is cleared.

c) Adjust the temperature for the new thermoplastic and run it in.

If you follow these basic procedures, right from the start you should mold parts of Delrin that fill the mold, have good surface, and are strong. Should you have trouble, check the "trouble-shooting" guide on page 627.

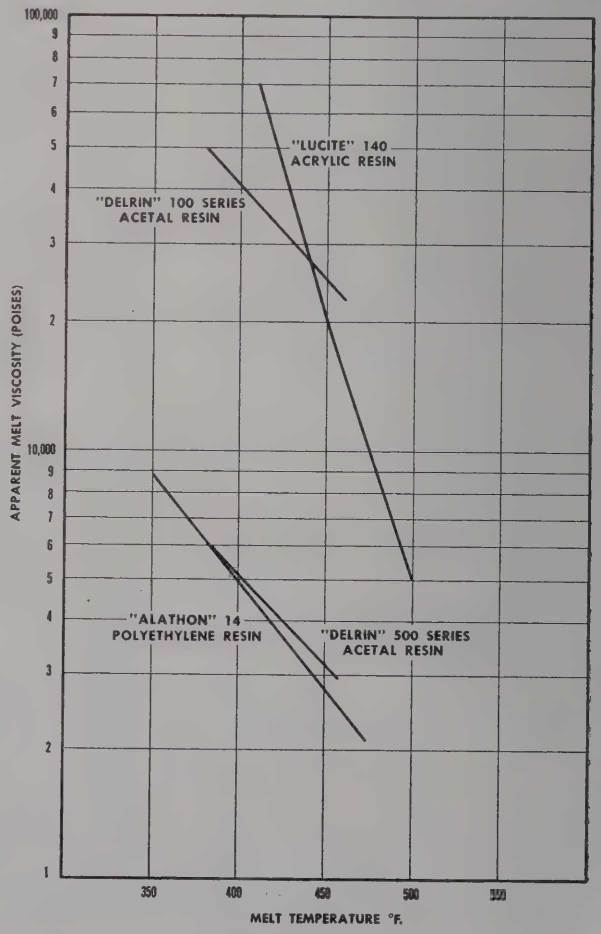

FIG. 3: Melt viscosity vs temperature for several thermoplastics, including acetal resin

INJECTION MOLDING: Acrylics

By G. G. Freygang*

Acrylic molding powders are available in Grades 5, 6, and 8 (A.S.T.M. D-788156 T). These three materials vary in softness, the softest polymer giving the best flow characteristics. The hardest molding powder has the best heat resistance.

A high-impact acrylic (Implex[1]) has recently come into general use. A discussion of its basic characteristics is presented later in this article.

Since dirt, lint, and dust will detract from the exceptional clarity of acrylics, careful handling and storage practices are of extreme importance. Because of the inherent tendency of practically all plastics to develop static charges, it is virtually impossible to prevent dust accumulation on reground material, even under ideal conditions. It is usually more desirable to use screened reground material in less critical parts than to blend it into virgin material.

Mold design

Well-designed molds are important to the production of well-molded parts. In multiple-cavity molds, balanced runner length, balanced gates, and balanced venting, if required, are all necessary to maintain uniform fill patterns (1).[2]

Runners should be designed to cause as little pressure loss and cooling of material as practicable. While the runners should be symmetrical and of equal length for uniform filling of multiple cavities, they should also be as short as practicable. The cross-section of the runner should have the greatest area with the least possible surface. Thus, a full round runner is ideal; $\frac{5}{16}$ in. in diameter if less than 10 in. long, and ⅜ in. in diameter if over 10 in. long. The sprue bushing should be at least $\frac{1}{32}$ in. larger in diameter than the runner, and the nozzle should be $\frac{1}{32}$ in. smaller than the bushing. However, sprue bushings smaller than $\frac{11}{32}$ in. are undesirable, regardless of the runner size. With fast injection speeds, short ¼-in. diameter runners have been used successfully.

A cold well should be inserted at the base of the sprue to trap the cold material from the nozzle before it enters the runners. This well also frequently serves as the means to pull the sprue through use of undercuts or "Z" pullers. This cold well should be slightly larger in diameter than the sprue at this point and approximately ⅜ in. deep.

In multiple-cavity molds, it is also frequently desirable to extend the primary runner beyond the most remote secondary runner to form a cold well.

There are some mold shapes which present difficult fill problems because of their contours, areas, etc. A "runner block," strategically placed, will frequently reheat the plastic sufficiently to overcome these problems. The restriction should be placed about ⅔ the distance from the sprue bushing to the cavity, but always in the primary runner. It should be ¼ to ⅜ in. long and may be reduced to about ½ the diameter of the runner.

Proper contour and placement of the gate is imperative. Gate shape may influence temperature and flow during filling. For proper gate design, it may be desirable to resort to one of the more specialized shapes, many of which have proven valuable. These include sprue, fan, tab, ring, diaphragm, spoke, etc. (1). Small round gates should impinge on a wall to prevent "jetting."

An air vent may be up to 0.003 in. in its smallest dimension and still prevent the plastic from flowing into it. A typical vent ground at the parting line may be 0.003 in. deep and ⅜ in. wide. When the air trap occurs away from an edge, the fill pattern of the mold must be changed before the trap can be eliminated. Sometimes merely relocating the gate will change the fill pattern so that the last part to fill is at an edge. In other cases, the necessary change may be accomplished by thickening the part to favor flow in a slow fill area, or reducing the thickness or introducing bosses in a rapid fill area, depending on the individual circumstances.

Adequate draft of 1 to 2° should be provided whenever possible, but some draft must be provided in all cases. Undercuts must be avoided. The knockouts should be well placed to move the part without undue local stress.

Pins are the most widely used type of knockout. The pins should be as large in diameter as possible so that the unit pressure on the part will be as small as possible. Stripper plates are frequently used in place of pins on molds such as tumblers, boxes, etc., where there is a thin, plane edge. Such parts as lenses, which cannot tolerate the scars caused by knockouts, may be removed by knockouts in the runners, if the gates are sufficiently strong and if there is adequate draft on the part. Tab-gated parts have been successfully handled with a single knockout in the tab. In a similar manner, knockouts can be used in bleeder tabs.

When the resulting scar can be tolerated, a spring-loaded poppet valve is sometimes used to admit air between the mold and the molded part, particularly with large-area flat parts and deep parts. Low pressure compressed air through such a valve is occasionally used for ejection.

Drying

Acrylic molding powders frequently must be dried to avoid excessive rejection rates. Because of their inherent tendency to absorb moisture until equilibrium is reached, they may contain considerable moisture (½% or more) at the time of use. Exposure to moist air, for even as short a time as an hour, will result in a considerable increase in moisture content (2).

The moisture content for critical jobs must be very low, approaching 0.02 to 0.04%. In noncritical jobs, moisture content of 0.15 to 0.20% can often be tolerated without excessive rejection rates.

Hopper driers and ovens can be

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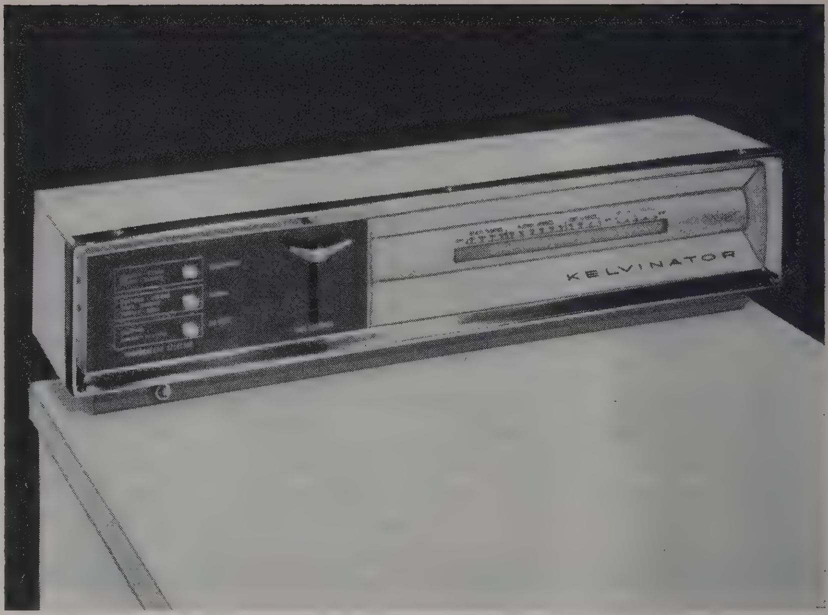
*Development Engineer, Rohm and Haas Co., Washington Square, Philadelphia, Pa.

[1] Trademark of Rohm & Haas Co.

[2] Numbers in parenthesis link to References, p. 599.

used for predrying. Grade 8 molding powder can be dried at about 210° F., or perhaps slightly higher, Grade 6 at about 190° F., and Grade 5 at about 170° F.

During periods of high temperature and humidity (high dew point), the air circulated in the drier must be dehumidified for satisfactory drying, particularly in the case of critical jobs. This stems from the fact that the equilibrium moisture content of molding powder dried in air having a high dew point is too high for trouble-free molding. Although this equilibrium level can be lowered by raising the temperature of the air used to dry, it may be impossible to dry sufficiently without caking the molding powder. Under these conditions, it is imperative to dehumidify the air circulated in the drier.



CONTROL PANELS for home appliances are injection molded of acrylic. Decoration (p. 794) can be accomplished by any of several methods.

Molding

The selection of injection machine size will have an influence on the quality and yield of molded parts. Normally, best results are attained if the shot weight is no more than 75% of the machine capacity. Molding above this percentage may produce material temperature variations within the shot and lower the available pressure at the mold. Excessive overcapacity of the machine is also undesirable.

The time cycles shown in the Table of Molding Characteristics, p. 623, are for parts of ideal design, well gated and vented. Poor or improper gates may increase these times. Special conditions, such as variable cross-sections, weld conditions, etc., in the mold cavity, may also increase the time cycle.

Shrinkage allowances (*F* in Table, p. 623) are greatly affected by shape and method of gating, as well as mold temperature, piston forward time, and pressure, and may vary from the values reported.

Stress-free moldings

It has been established (3) that the most stress-free molding will give the best service with respect to dimensional stability at elevated service temperatures, resistance to chemical attack, and long-time outdoor exposure. Molding at moderate-to-high material temperatures, with adequate but not excessive pressure, into warm and carefully controlled molds will produce the most stress-free parts (4).

Annealing will tend to redistribute and lower the inherent molding stress and will produce superior parts. Annealing is imperative if the parts are to be decorated by painting or lacquering. Annealing, however, is not a means to overcome poor molding practices.

High-impact acrylics

High-impact acrylics are used where transparency is not needed and toughness—even greater than that found in the standard acrylics—is desired. Other advantages include greater resistance to staining, lack of unpleasant odor or taste, high surface gloss, dimensional stability, chemical resistance, and stiffness.

Implex, the only commercial high-impact acrylic, is off-white and translucent in its natural state and can be produced in a wide range of opaque colors. Several grades are available to meet requirements for different combinations of properties. Implex A and B are the most widely used.

Most of the foregoing statements regarding predrying of acrylics also apply to high-impact acrylics. Implex A can be dried at temperatures up to about 210° F., while Implex B should be dried at about 190° F. Since prolonged drying at elevated temperatures in contact with air gradually produces a discoloration of the material, high-impact acrylics should not be dried longer than 16 hours.

Mold design

To obtain optimum molded parts, the high-impact acrylic should fill the mold while still hot. Therefore, runners should be as short as possible and properly designed to deliver hot material. The sprue and nozzle should be sized to adequately fill the part without holdup. For many jobs a 9/32 in. nozzle, 11/32 sprue, and 3/8-in. diameter, full-round runners will produce a well balanced fill system. In some cases, a runner block placed near the cavity will reheat the material as it approaches the cavity and produce parts that are superior.

In general, fill times of 4 to 8 sec. produce the best parts. (Extremely heavy section moldings must, of course, be molded by the conventional slow, cool technique.) Because of the desirable rapid fill times and of the tendency to jet into the mold, the gates must be properly designed. They should be placed and sized so that the incoming material can impinge on a wall and immediately form an expanding envelope. If it is impossible to impinge on a wall, then the gate thickness should be approximately ⅞ of the wall thickness so that the first material to enter contacts the mold face and forms the envelope.

Proper vents will aid the desired fast fill and will provide escape for air and volatiles. Frequently a dullness on the surface of the molded part in areas remote from the gate can be eliminated by better venting.

The mold shrinkage of high-impact acrylics is in the general range of 4 to 8 mils/inch. Since shape and fill patterns also influence mold shrinkage, molds for critical parts should be made so they can be adjusted, or sample cavities should be made.

The toughness and extensibility of high-impact acrylic frequently permit stripping molds with undercuts. The less rigid behavior suggests adequate knockout area on the parts to prevent "whitening" at the knockout pins or overall distortion of the part.

Much of the material given under mold design of acrylics also applies to high-impact acrylics.

Molding

Cylinder temperatures of 400 to 500° F. are recommended. It is usually desirable to set the higher temperatures at the front of the cylinder and keep the rear at the lower range. Generally, cylinder temperatures for Implex B are 30 to 40° F. lower than for Implex A.

Mold temperature should be controlled by circulating water. Hot molds, in the range of 170 to 180° F. for Implex A and 160 to 170° for Implex B are most desirable. Mold temperatures as low as 135° F. may be used to speed cooling if these lower temperatures do not restrict fill rates or reduce gloss on molded parts.

Injection pressures will usually be moderate to high—15,000 to 20,000 p.s.i. at the injection plunger—to produce rapid filling and good molding.

References

1) "Runner and gate design," Modern Plastics *34*, 166 (Oct. 1956).

2) "Predrying of molding powders," by F. I. McCash, Modern Plastics *34*, 120 (Aug. 1957).

3) "New gating for acrylics," by J. F. Moore, SPE J. *13*, 17 (March, 1957).

4) "Service temperature characteristics of molded acrylic parts," by Gouza and Robertson, SPE J. *12*, 19 (Sept. 1956).

INJECTION MOLDING: ABS polymers

By C. R. Holt*

General molding techniques used for the common thermoplastics work well with the acrylonitrile-butadiene - styrene copolymer (ABS) resins but certain specific recommendations should be followed.

The ABS resins are available in various types or grades for use in molded items requiring maximum toughness at high hardness and tensile strength, high gloss, rigidity, and mar resistance. They do not have a sharp melting point but soften gradually as the temperature is increased beyond the heat distortion point. Exact temperature recommendations for each grade of resin should be obtained from the manufacturers.

Molds for ABS compounds should be constructed along conventional lines, bearing in mind the need for adequate pressures, generous runners, and comparatively large gates. Details such as internal ribs help the plastic flow to the far ends of the cavity. Runners and mold surfaces should be highly polished for best flow of material and fine finish on the molded parts. Molds should be vented adequately where needed to prevent gas burns.

Short runners

All multi-cavity molds should be designed with the shortest possible runners and having gates balanced for uniform fill of each cavity. Major runners should be extended slightly beyond furthest secondary runners to act as cold slug traps. Adequate venting of cold slug traps will help eliminate gassing in the cavities.

Runners should be full round and not less than 0.250 in. for comparatively small parts and proportionately larger for large parts. Sprue bushings should be selected for size to conform with major runner dimensions.

Water channels in the runner plate help keep the plastic hot as it flows through and into the cavities. A cold slug well at the end of the sprue should be provided whenever possible. This should run ⅛ to ¼ in. larger in diameter than the sprue and be sufficiently deep to accommodate large nozzle slugs.

Proper design of gating is very important for producing parts with good appearance. Conventional gates should be rounded and streamlined, preferably widened at the cavity end with the shortest possible land length from the end of the runner. Large gates should enter a heavy section of the part, not flush with a finished surface, to promote rapid fill from thick to thin areas. Gating into a finished surface may result in a blemish at the gate area. In this respect, gates should be located in the least conspicuous areas of the finished part. Sprue and tab gating has proved very successsful. Submarine gating is not normally recommended because of gate size limitations, but excellent parts of small surface area have been produced with such gates.

Gate blush and jetting effects can be prevented by locating the gate so as to flow the resin into the cavity and against a baffle type of obstruction, which might be an opposing wall, core, or boss. This will allow the hot plastic to flow uniformly in a "blossom" and so eliminate flow marks. Fanning out or widening the gate at the cavity edge can also help eliminate gate blush.

Molding techniques

In the injection molding of ABS resins, shot size should normally not exceed 75% of the nominal shot capacity of the press. As the part size increases, or as surface area becomes greater, the ratio of press capacity to shot size should be increased and the gating be more generous.

ABS resins must be pre-dried

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*Market Development Mgr., Marbon Chemical, Washington, W. Va.

thoroughly prior to molding. A drying period of at least two hours at 180 to 200° F. is best. Preheating can be done by the use of conventional air circulating tray ovens. When using tray driers, a layer of pellets ¾ to 1 in. deep is generally satisfactory. Tray dried material should be transferred to the hopper of the machine as quickly as possible, the level of the material being kept fairly low so that it will enter the heating cylinder as soon as possible. Hopper heaters can also be used to good advantage.

Potential moisture defects are very noticeable in purging the ABS resins. The rope will be full of bubbles or air pockets. Moisture or mica marks will be noticed on the molded parts. This results in poor finish and low physical properties.

Molding of a part should be started with low cylinder temperatures (375 to 425° F.), hot mold (170 to 180° F.), largest possible gate and nozzle, maximum pressure, and generous cycle. A trial air shot should be taken to inspect plasticity, color, and appearance. The rope should be smooth, glossy, and nonporous, without lumps, particles, discoloration, contamination, or large blisters. After locking the nozzle against the bushing, temperatures can be gradually increased until complete fill is obtained. Normal top cylinder temperatures are 475 to 500° F.

Cycle time can then be reduced to the point of short shots by reducing injection time, then total time. Inability to get full shots on a long cycle over a wide temperature range, or the necessity of increasing molding temperatures more than 50 to 75° F. over that of the air shot, shows that larger gating is needed.

The nozzle and front zone of the heating cylinder should be set at optimum temperatures and the rear zone varied to partially control the speed of the injection ram and for the control of the temperature of the melt.

Mold heats in the 160 to 180° F. range are recommended for obtaining maximum gloss and fill of the cavity, and for obtaining reasonable cycle times without short shots or sink marks.

Higher cylinder and mold temperatures increase dimensional stability of the molded part for service at elevated temperatures. Annealing of molded parts (1 hr. at 175 to 200° F. in hot air) improves the dimensional stability of parts molded at lower cylinder temperatures; that is, annealing has the same effect as molding at higher heats. For maximum impact strength, cylinder heats are normally carried as low as possible.

The ABS resins are not corrosive to equipment, even if badly heat degraded. Purging of the press after a run of ABS resin should be practiced, however, to prevent decomposition and subsequent hang-up which might contaminate suceeding runs. Stiff flow plastics are generally best for purging and acrylic is often used. An even better technique is to use polyethylene pellets with a cylinder temperature range low enough to keep the polyethylene stiff—heats of 350 to 375° F., for example.

Molded properties

Warm parts just out of the press, especially in the darker colors, always should be handled with clean cotton gloves to prevent marring or finger marking. Wrapping or packaging should be done with soft paper or polyethylene film after the parts have cooled to room temperature.

ABS parts are often held in conventional freeze jigs upon removal from the press. Thick parts are sometimes shock cooled in a water bath to prevent sinking; it is advisable to use water as hot as possible to prevent blowing, porosity, and trapped stresses.

Weld areas of molded ABS parts are exceptionally strong and are not normally weak sections.

Annealing of molded parts may be necessary in special cases and this should follow established techniques: uniform heating of the part to a temperature 10 to 15° F. below the heat distortion point, followed by slow gradual cooling. Time and temperature of annealing will be specific for each case, depending upon the contours and thickness of the part.

INJECTION MOLDING: Cellulosics

The four types of cellulose plastics having volume usage for injection molding applications are cellulose acetate, cellulose propionate, cellulose acetate butyrate, and ethyl cellulose. Each has its distinguishing characteristics, but being of the same family they are similar in a number of ways. In particular, these plastics are noted for their toughness, dimensional stability, surface appeal, almost unlimited color range, heat stability, and ease of molding and fabrication. They are all prepared from their basic polymers into workable plastic form by compounding with proper plasticizers.

A number of different plasticizer types are used, and it is quite common to combine two or three to advantage. By virtue of the modifications which can be made in formulation, very broad ranges of physical properties and molding characteristics are possible. Through proper selection of base polymer, and type and amount of plasticizer, specific property combinations can be "designed" into the plastic.

Predrying: To obtain good results in molding cellulosics, proper drying is essential, particularly since these plastics are slightly hygroscopic in nature. Presence of excessive moisture is cause for such defects in the molded piece as surface mica, blisters, and bubbles. Drying of the granules to a moisture content of 0.2% or less is recommended. This may be accomplished in the following manner:

Type of equipment: Hopper dryer or circulating-air oven (tray dryer)
Drying time, hr: 2 to 6
Dry temp., °F.: 160 to 200

In hopper dryers, the higher temperature levels up to 200° F. can be used if it is known that the material in use will not tend to lose its plasticizer through volatilization or become tacky and bridge across the hopper throat.

If a tray dryer is used, the recommended depth of granules in the trays is about ¾ inch.

Infra-red dryers can also be used. Among infra-red dryers, those best suited to production use are endless-belt or vibrating-conveyor units, which in a continuous type of operation pass the granules in a thin layer under infra-red lamps for a controlled exposure.

Handling: Care in handling to avoid contamination is necessary, but no special handling conditions are required.

Equipment and molds

Equipment: No special equipment is necessary when molding the cellulosics. Certain recommendations are offered, however.

For example, a heater band for the *nozzle,* with separate Variac control, is recommended. Generally, 100 w. is adequate. The heat should be adjusted to give a slight pull-out of plastic melt on the nozzle end of the sprue.

Large-hole nozzles are also preferred for easier fill because they lessen pressure loss. The size, however, will necessarily be slightly under that of the sprue's minimum diameter.

Recommended materials of construction for *cylinders and spreaders* are S.A.E. 4140 or 4340 steels.

Mold design: Identical-cavity layouts are highly preferable to "family" molds from the standpoint of balanced flow, simultaneous filling, and minimizing of flash. A flash chrome plating of cavities is recommended.

Gating: See Table, p. 623, Section D. Dimensions listed in Table are based on the restricted type of gate and are applicable as starting recommendations for all cavity sizes within the given limitations. Gates may be enlarged, particularly in the large-size heavier-thickness cavities, if necessary.

Except possibly for relatively large moldings, the restricted gate has a number of advantages over the full-open type. Properly applied, it provides improved uniformity of flow-out, minimizes turbulences and resultant stresses, and enables better escape of gases from the cavity. Also, more rapid setup at the gate acts to eliminate sinks and flow-back and in turn enables a shorter piston-forward time in cycle. Another advantage is reduced trimming and finishing.

At the same time, the tendency for somewhat lower impact strength to occur near the gate area should be kept in mind. Generally, with restricted gating, it is desirable to gate into the thin cross-section end of a cavity. The plastic should enter the cavity in a direction perpendicular to the main direction of flow within the cavity and directed against an opposing wall or pin so that the center of flow is dispersed. This provides more uniform fillout and eliminates "worming."

The molding of mottles through restricted gating will result in a blending-out effect, but as the diameter approaches 0.050 in., quite a good pattern can be obtained.

Runners: A recommended layout of cavities and runner system would feature the following: 1) equal runner distance from sprue to all cavities; 2) a balance in cavity distribution by having an equal number per runner and per branch of runners; 3) full-round runners; 4) a stepwise reduction of 1/32 in. in runner diameter from sprue to cavities at each branching of the system; and 5) an over-run of the runners past the gates, or past the secondary sprues if center-gated, and also at appropriate junctions in the system to function as cold-slug wells.

As a rule, runner diameter can be gaged by the thickness and size of the piece to be molded. Common sizes are 1/4 to 5/16 in. with a minimum of 3/16 in. recommended. Oftentimes, undersized runners rather than gate size are cause for such difficulties as mica, lamination, and lack of ease in mold fill. Thus, it is advisable when using restricted gating to be assured that runners are adequate before opening the gates. A runner connecting to a gate should not be tapered in its approach but should be kept full and should end in a hemispherical contour. This helps to minimize pressure loss.

Molding characteristics

See table, p. 623. To cover this extremely broad class of molding compounds over the flow grades commercially available, fairly wide ranges are used in tabulation of figures appearing in the table. Some of the softer compositions can be molded as low as 350° F., whereas the harder, less-plasticized formulations may require as high as 500° F. Allowance for differences in injection molding machines, type of part being molded, mold design, etc., was also taken into account.

The approximate operating conditions are therefore offered only as a guide for start-up.

Cylinder temperature: A good rule-of-thumb, regardless of type or formulation, is to work at the highest cylinder temperatures feasible for good operation. This is important, particularly for the harder, higher-flow materials, in order to develop maximum impact resistance and elongation, to minimize molded-in stresses, and to avoid weak welds. This temperature is generally slightly below the point at which traces of discoloration occur. Some exceptions to this are found where other limitations are encountered prior to reaching this temperature level, i.e., defects such as flash, sinks, voids, heat marks, and vapor burns. These exceptions will occur for the most part with the lower-flow materials, where the need for approaching the discoloration point assumes less significance.

In molding ethyl cellulose, particularly where relatively thin sections are required, use of maximum allowable temperatures should receive special emphasis. If molded on the "cold" side, the piece may look good but is likely to be laminar, or have a peelable surface skin, and will tend to dull or "rup-up." Higher-flow grades are more apt to show these defects than the softer compounds.

Flow temperature, as measured by the standard A.S.T.M. test, D569-48, is commonly used with the cellulosics as a means for control and identification. This is the temperature at which a plastic under 1500 p.s.i. pressure will flow through a standard 1/8-in. orifice for a distance of 1 in. in 2 minutes. It is recognized that the rates of shear and the conditions of temperature and pressure, in addition to other basic differences, are quite unlike those occurring in an injection molding process. For these reasons, the test is not a precise indication of relative molding characteristics, unless the plastics compared are from a given polymer-plasticizer system. Therefore, for example, it is not at all uncommon to have two cellulose acetate plastics of the same flow which differ significantly in molding characteristics.

In view of this, an unqualified use of flow to indicate molding temperatures should be considered as only a rough guide for start-up.

If the melt in the cylinder is kept hot too long, it degrades. Top safe temperature for 20-min. exposure is 350 to 400° F.

Approximations for average conditions are as follows:

Flow[1]	Cylinder temp. (°F.)
H4 — H5	455 — 510
H2 — H3	435 — 495
MH — H	405 — 465
MS — M	370 — 430
S2 — S	340 — 400

[1] See A.S.T.M. test D569-48. 1955 Book of A.S.T.M. Standards, Part 6, p. 287, for definition of these flow designations.

Nozzle temperature: If the nozzle or cylinder heats are excessive, the plastic will drool. This is not only a waste of plastics but is objectionable in that some of the oozed material enters the sprue bushing prior to the injection stroke, becomes chilled, and may cause plugging at the cavity gate or surface defects in the part.

Mold temperature: Precision work requires close control. Proper coring of the die and a temperature-control unit capable of maintaining the circulating water at ±2° F. are essentials. Optimum temperature level will depend primarily on size and thickness of the part and on the plastics formulation. For relatively high-flow compositions, especially where long, very thin sections are being molded, temperatures as high as 180° F. may be needed. For the softer formulas, a low in the vicinity of 70° F. is not uncommon. However, most jobs will fall within a 120 to 160° F. range. For obtaining maximum surface gloss, plus minimum weld lines and flow marks, the highest temperature which will provide adequate set within the cycle limitations should be used.

Pressure: In general, the optimum is a combination of maximum pressure and minimum booster which will provide unhesitating fill without encountering flash or sinks.

Cycle: The cycle is primarily governed by section thickness, plastics formulation, cylinder temperature, die temperature, and the ease of ejecting the molded part from the cavity. The injection portion of the cycle should be of adequate length for setup to occur at the gates of the cavities. Otherwise, flow-back, with resultant sinks or voids in the part, will occur. The cooling portion of the cycle should then be the minimum needed for prevention of distortion on ejection and during further cooling.

Purging routine: Purging is done with commercial purging compound, scrap, or the material to be molded. Purging is generally necessary at start-up, after excessive heat exposure, or when changing materials.

Design of molded part

Prior to new die construction, first consideration should be given to the design of the article.

Dependent on design and important for successful molding are: 1) flow of the plastics in filling the cavity; and 2) ease of ejection of the molded part.

The general shape and dimensions of the proposed molding and the gate location are principal factors affecting flow through the cavity. Their combined influence should be directed toward achieving an unhesitating, balanced progression of the plastics during cavity fill. If flow from the gate to the extremities is not uniform, or if the flow becomes divided, trapping of gases and weld lines are likely. Wall thickness is a very important controlling feature, and even small variations toward an unbalanced condition can cause trouble. Sudden changes in the thickness should also be avoided because of a shrinkage differential on cooling, which is likely to cause distortion or highly stressed areas. On center-gated items, it is good practice to provide a gradual decrease in the wall dimensions as the distance from the gate increases. This tends to prevent unbalanced fill; furthermore, with deep-drawn parts, the draft obtained is necessary for ejection.

Where holes and inserts are required, it is well to avoid, if possible, square or rectangular shapings, since flow at these points tends to cause a weld line and also pigment orientation.

No matter what the final design, however, the recommended molding conditions listed in the table on p. 623 can be taken into account. These recommendations have been broken down to provide for variations caused by differences in section thickness.

INJECTION MOLDING: Nylon 6/6

By Louis Paggi*

Successful molding of nylon requires consideration of certain factors. For example, nylon has a sharp melting point (e.g., 487° F. for Zytel[1] 101). At molding temperature, it has a lower melt viscosity than conventional thermoplastics. It is therefore necessary to modify conventional equipment and procedures for molding.

Plasticating cylinder: With a correctly designed nozzle and proper distribution of heat, injection cylinders of all designs can be used for molding nylon. In general, it is found that horizontal diverging-type cylinders (Fig. 1 and 2, p. 603) and vertical cylinders can be heated to a higher over-all temperature than is possible with horizontal straight-bore cylinders.

Failure to carry sufficiently high temperatures at the rear section of diverging and multichannelled cylinders may result in bridging of the granules, causing drooling at the nozzle, loss of injection pressure, local degradation of the material, and reduced output.

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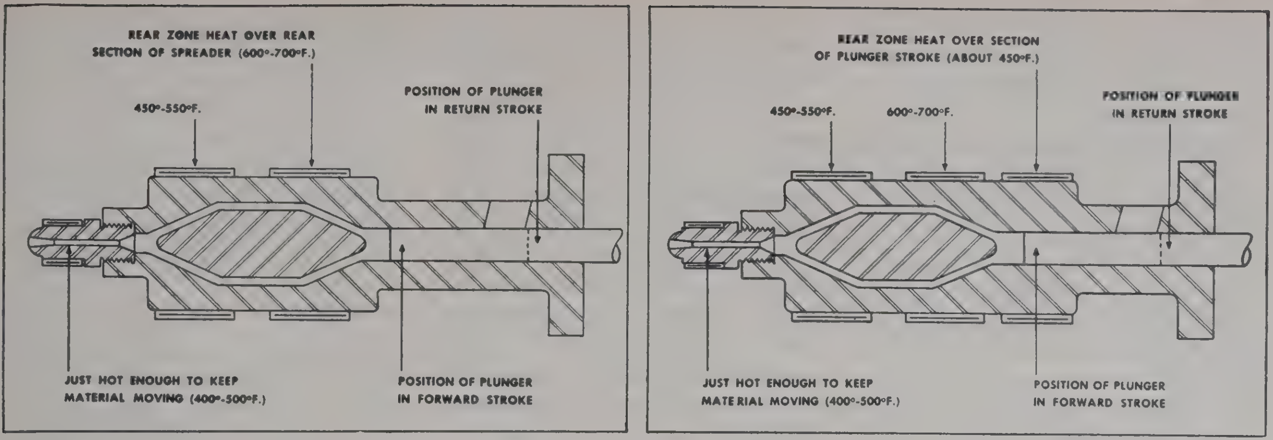
*Polychemicals Sales Service Laboratories, E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.

[1] Trademark of E. I. du Pont de Nemours & Co., (Inc).

References were prepared by the editors.


REAR ZONE HEAT OVER REAR SECTION OF SPREADER (600°-700°F.)
450°-550°F.
POSITION OF PLUNGER IN RETURN STROKE
JUST HOT ENOUGH TO KEEP MATERIAL MOVING (400°-500°F.)
POSITION OF PLUNGER IN FORWARD STROKE
REAR ZONE HEAT OVER SECTION OF PLUNGER STROKE (ABOUT 450°F.)
450°-550°F.
600°-700°F.
POSITION OF PLUNGER IN RETURN STROKE
JUST HOT ENOUGH TO KEEP MATERIAL MOVING (400°-500°F.)
POSITION OF PLUNGER IN FORWARD STROKE

FIGS. 1 and 2: With proper distribution of heat, injection cylinders of all types can be used for molding nylon. Of the two major types of heater distribution, the cylinder in Fig. 1, (left) requires higher rear zone temperatures because the heater band does not extend over the plunger path, as in Fig. 2 (right)

The type shown in Fig. 1, (typified by the De Mattia, HPM, Impco, Fellow-Leominster, Reed-Prentice, and Watson-Stillman machines) has no heating band over the course traveled by the plunger. The rear heating zone is at the rear section of the spreader. For this type of cylinder, the highest temperature (600° F. or hotter, depending on thickness of section, cycle, etc.) should be maintained at the rear band (measured at the center of the heater band). A temperature about 50 to 150° F. lower is maintained over the front portion of the spreader section. The temperature at the extreme front end of the cylinder should be just high enough to keep the material moving through the nozzle—as low as 400° F. on fast cycles, or as high as 500° F. on slow shots.

In the cylinder design shown in Fig. 2 (exemplified by the Lester and Van Dorn machines), the rear heating zone overlaps a section of the plunger stroke. The rear band of such a cylinder should be heated only to about 450° F. The higher temperature is applied at the main body bands. For the front portion of the spreader and the extreme front end of the cylinder, the same general rules apply as for the cylinder in Fig. 1.

Nozzle: Recommended for molding nylon is a nozzle with a reverse taper bore at least 1 in. in length. This, in effect, extends the sprue into the heated nozzle. This design permits operation of the nozzle at a lower over-all temperature, eliminates the likelihood of a hot spot at the rear of the nozzle, and provides good control over drooling. For the best results, this type of nozzle should be provided with a heater band of sufficient wattage to maintain a temperature of at least 600° F. This band, located as close as possible to the outlet of the nozzle and the sprue bushing, should not exceed 2 in. in length.

It is important that the nozzle be adjusted to the sprue bushing only after the plasticating cylinder is up to molding temperature. If the nozzle is tightened against the sprue with a cold cylinder, the thermal expansion of the cylinder will wedge the nozzle too tightly against the hard sprue bushing, causing peening-in of the front opening. A damaged nozzle is hard to control.

Several available machines are now equipped with nozzles having mechanical shut-offs This type of nozzle has proved successful in molding nylon; in fact, it offers certain advantages when molding over inserts, or when very hot material is required at the front end of the cylinder, as when molding extremely thin-walled sections.

Mold design: Special mold construction is not required for nylon. Although molten nylon is more fluid than other thermoplastics, it will solidify almost at the instant of contact with the relatively cold mold surface, thus eliminating any undue tendency to flash. When flashing occurs, the line pressure should be reduced but the high rate of injection maintained. It should be noted that a common cause of flashing, as well as surface burns, is due to insufficient venting of the cavities. Because of the high rate of injection necessary for nylon, good venting of cavities is important at the spot where air traps. The preferred method of venting is an overflow button or slug positioned diametrically opposite the filling gate and connected to the cavity with a gate and runner of approximately ½ the cross-section of the filling gate. Rough ground parting lines are a second choice.

Lapping of the mating surfaces of the cavities is not recommended when injection molding.

Molds for articles which do not demand close tolerances can be designed by using data accumulated through experience or by allowing for a shrinkage of 0.010 to 0.040 in./in., depending on the wall section of the article. When close tolerances are required, however, the following mold construction steps are recommended:

1) Using the specified dimensions, machine a single cavity in the mold-base.

2) Machine the sprue bushing and all runners up to the positions where the production cavities will be inserted. This will establish the time required for the material to reach the cavities.

3) By trial moldings in the single cavity, determine optimum runner and gate size, and the best molding conditions.

4) Heat-treat the molded part for ½ hr. at 350° F., and allow to cool slowly.

5) Check dimensions of the treated article after at least 24 hours. Note changes in any dimension.

6) Use shrinkage data thus obtained to adjust the dimensions of the production mold which is to be constructed.

Runners: In general, runners should be between 1/16 and 3/8 in. in diameter. For articles having a wall thickness of 1/8 in. or less, runners need not exceed 1/8 in. in diameter. For articles of heavier wall thickness, the diameter of the runners should usually be about 1/2 to 2/3 the thickness of the article, though not exceeding 3/8 in. in diameter.

Gates: Dimensions for gates are given in the table on p. 624. If possible, gates should be flared toward cavities.

Predrying

Material molded with a moisture content above 0.25% will give moldings or extrusions with reduced toughness. The molding powder should therefore be stored in covered, moistureproof containers. Hoppers of machines should also be covered to minimize contamination by moisture.

It is recommended that nylon be molded fresh from the can. After opening the shipping container, nylon molding powder can stand (on humid days) for only 20 min. before predrying is necessary. Drying can be done in a dehumidified air oven at 175° F. Drying time would be between 3 to 6 hr. for virgin material and 12 to 24 hr. for reground material.

Molding characteristics

See table on p. 624.

Molding temperatures: In many cases, the use of higher molding temperatures (600 to 700° F.) improves the properties of the molded piece (especially toughness), permits the use of smaller runners (hence gives less scrap and shorter cycles), and increases the plasticating capacity of the machine from two to four times that possible with temperatures of 550 to 600° F.

Moldings of thin section, produced in short cycles and at high rates of material consumption, require higher cylinder temperatures than moldings of heavier section, longer cycles, and low rates of material consumption. For example, in the case of a 6-oz. shot being molded on an 8-oz. machine at a rate of about 11 lb. of nylon per hr., a temperature of 520 to 600° F. is indicated. If the same 8-oz. machine is used to mold a 2-oz. shot every 20 sec. (or about 22 lb./hr.), a higher temperature will be required. An output of greater than 40 lb./hr. on the same machine may necessitate cylinder temperatures as high as 720° F.

Mold temperatures: In general, the temperature of the mold should be about 160° F. Lower temperatures may be used when extreme toughness in thin sections is desired. Temperatures as high as 250° F. may be used when a more stress-relieved article is desired but where extreme toughness is not absolutely necessary.

Molding cycles: Articles with nonuniform cross-section, in which edges or surfaces must be extremely straight or flat, will usually require longer cycles.

Purging routine: After 5 min. delay, purge repeatedly until ram labors. Repeat as necessary.

Heat-treating

To insure against any dimensional change caused by stress-relief, it is important that residual stresses be relieved by heat-treating the articles soon after molding. (Sec. E of table, p. 624.)

It is recommended that heat-treating of nylon be carried out in the absence of air, preferably by immersion in a suitable liquid. The temperature of the heat-treating liquid should be well above the temperature to which the article of nylon will be exposed in use, preferably about 350° F. This will insure against dimensional change caused by uncontrolled stress-relief occurring below this temperature. Upon removal from the heat-treating bath, the molded article should be allowed to cool slowly in the absence of drafts; otherwise new surface stresses may result. A simple way of insuring slow, even cooling is to place the heated article in a cardboard container.

High-boiling hydrocarbons, such as oils or waxes, may be used as heat-transfer medium if the deposit left on the surface of the article is not objectionable. The minimum immersion time required for heat-treating is 10 min. for articles having a wall thickness less than 1/8 inch. Articles of heavier cross-sections may need up to 30 minutes.

Hazards

Nylon is not a dangerous material to handle, provided it is recognized that it is very hot and very fluid in its molten state.

In general, molding powders heated to elevated temperatures in a confined space expand considerably and generate pressure which, when released, can cause molten material to be expelled from the cylinder with considerable force. Long delays in the molding cycle increase the possibility of violent ejection, particularly if the material in the rear section of the plasticating cylinder and the material in the nozzle are allowed to solidify due to a temperature drop, while the center and front sections are maintained at well above the melting point. This results in the formation of a solid plug of plastic at either end of the molten material under pressure. To prevent this from happening, the nozzle should be free from contact with the sprue bushing during the heating period prior to molding. The nozzle and front end of the cylinder should be heated first and maintained at a temperature at least 50° F. above the rest of the cylinder. As soon as the plastic flows from the nozzle, the remainder of the cylinder may be set to the proper molding temperature. When the rear temperature is sufficiently high to permit moving the ram, at least one air shot should be taken before locking the nozzle against the sprue bushing. The rear temperature of the cylinder should then be maintained high enough to allow free movement of material entering the rear zone.

If the melt in the cylinder is kept hot too long, it degrades and the molded pieces may suffer from such defects as discoloration, brittleness, poor surface, etc. The top safe temperature for 20-min. exposure is 550° F.

INJECTION MOLDING: Nylon 6

By Damon Simpson*

Nylon 6 molded parts have physical and electrical properties quite similar to those of nylon 6/6; however, there are several differences in molding characteristics which should be noted.

Melting point: Nylon 6 has a melting point about 60° F. lower than nylon 6/6 (e.g., 425° F. for Spencer Nylon 401[1]). Thus, it is possible to operate the molding equipment at lower cylinder temperatures.

Processing range: Since both types of nylon have approximately the same upper limit on processing temperature, the type 6 nylons, because of their lower melting point, have a broader processing range.

Mold temperature effect: When molding thin-section parts (less than ⅛ in.) from nylon 6, physical properties can be varied to a greater extent by adjusting mold temperatures than is possible with nylon 6/6. A cold mold (below 100° F.) results in parts with higher impact strength; sections less than 0.040 in. thick will be transparent. A hot mold (above 150° F.) produces parts with higher tensile strength, yield point, flexural stiffness, and surface hardness.

Molding equipment

Nylon 6 can be processed in any of the commercial injection molding machines. Either the straight-bore or diverging-type cylinder may be employed; however, the nozzle should be designed to eliminate the possibility of drooling. This can be accomplished with a mechanical shutoff or with a reverse-taper nozzle. The latter should have at least ½ in. of reverse taper and the nozzle should be equipped with a heater band of sufficient wattage to maintain 550° F. It is a good practice to have a separate controller for the nozzle heater band, since it is quite often desirable to operate the nozzle at a temperature different from the front zone of the cylinder.

Mold construction: Conventional mold materials may be used in constructing molds for nylon 6. Polished steel is most commonly used in the construction of cavities; in some cases cavities are chrome-plated to prevent the formation of rust while the mold is not in use. Cavities of beryllium-copper alloys have been successfully used with nylon 6.

Mold design: Since nylon 6 has a lower mold shrinkage than many of the other thermoplastics, proper sprue taper and cavity draft should be employed. A minimum taper of ½ in./ft. and a minimum draft angle of 1.5 degrees is recommended. It is advisable to undercut the cold-slug well opposite the sprue bushing on the moving half of the mold to eliminate the chance of having the sprue hang in the bushing.

Whenever possible, full round runners from ⅛ to ⅜ in. in diameter should be used. Table I, below, indicates the recommended diameters and maximum runner length for various part thicknesses. In cases where it is necessary to have the runner system entirely within one-half of the mold, runners with trapezoidal cross-sections, may be used.

Nylon 6 will work quite successfully with either conventional gates or submarine-type pinpoint gates. The table of injection molding characteristics, p. 625, lists the recommended gate sizes.

Molding characteristics

It is usually unnecessary to dry nylon 6 before it is placed in the hopper since the moisture content of the virgin resin is well below the critical point of 0.3 percent.

Cylinder temperatures: The rate at which the nylon must be plasticized will be the determining factor in selecting the proper temperatures for the various zones of the cylinder. Generally speaking, thin-section parts molded on a short cycle will require higher temperatures than heavy-section parts on a longer cycle. Some of the type-6 nylons have higher melt viscosities than others and therefore will require slightly higher temperatures.

Injection pressure: Nylon 6 should be molded with injection pressure as high as possible, consistent with flash-free parts. With nylon 6 this will usually be from 70 to 100% of hydraulic capacity. Since the amount of unmelted pellets in front of the ram can change the effective pressure on the plasticized material, this volume of unmelted resin (cushion) should be maintained as constant as possible by consistent feeding.

Cycle: Mold design and part thickness affect cycle time. Cycles will be longer when the plasticating capacity of the machine is heavily taxed.

By utilizing various combinations of cylinder temperatures, injection pressures and mold temperatures, it is possible to vary the mold shrinkage of nylon 6 parts from about 7 to 29 mils/inch. Generally speaking, low mold shrinkages will result with high cylinder temperatures, high injection pressures and low mold temperatures. Higher shrinkages can be obtained with lower cylinder temperatures, lower injection pressures and higher mold temperatures.

Post conditioning

Over a period of six months or more a nylon part will gradually become annealed and also will absorb moisture from its environ-

TABLE I: Recommended runner sizes for nylon 6

Runner diameter	*Maximum length of runner from sprue bushing to nearest cavity*	*Maximum thickness of parts to be fed*
in.	*in.*	*in.*
⅛-³⁄₁₆	6	³⁄₁₆
¼-⁵⁄₁₆	12	½
⅜	15	¾

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* Staff Assoc., Sales Service Laboratory, Spencer Chemical Co., Kansas City, Mo.

[1] Trademark of Spencer Chemical Co.

ment. These two events will change the dimensions of the part to a certain extent.

Where close tolerances must be held, it is quite often necessary to accelerate these natural occurrences by post-conditioning. This entails annealing the molded part at elevated temperatures and also providing a means for moisture conditioning.

Annealing: This stress-relieving operation is usually conducted at 275° F, for nylon 6; it results in a slight shrinkage of the part. Several heat transfer mediums may be employed, including high-boiling waxes and oils (See table, p. 625. A nitrogen-atmosphere oven may also be used. After the parts are removed from the annealing medium, they should be placed in an insulated container (such as a corrugated cardboard box) and subjected to slow cooling.

Moisture conditioning: The moisture conditioning step expands the part at the rate of about 2 mils/in. for each 1% increase in moisture content. It can be conducted by immersing the part in hot water between 180 and 200° F.; the time required to obtain the desired moisture content (2.5 to 3.0%) will be approximately as follows: ⅛ in. section: 2 hr.; ¼ in. section: 4 hours. In cases where both post conditioning treatments are used, the moisture conditioning step should follow annealing.

INJECTION MOLDING: Low-density polyethylenes[*]

By Ralph M. Knight[†]

The low-density polyethylenes available for injection molding give a wide choice in melt index. Figure 1, opposite, which plots melt index ranges against cylinder temperatures, shows the relation between the temperature required for mold fill and the melt index of various resins that might be used for the job. The diagonals are lines of constant ram pressure.

For example, if the molder uses a resin of melt index 3.0 at a barrel temperature of 550° F., he is operating at point A. If he wants to reduce the molding temperature with no change in pressure, he may do so by choosing an easier-flow resin of melt index 8.0, provided this resin will give the molded item all the desired properties. Sliding down along the diagonal constant-pressure line running through point A until, at point B, he is in the desired area, he finds that a temperature of only about 445° F. would be required for the same mold fill with the higher-melt index resin. This is 105° F. lower. If he thinks he can use a resin of still higher melt index at a still lower temperature, he may slide further down along the constant-pressure line until, at point C, he is in the 22.0 melt index area at about 335° F.

Besides the advantage of molding at lower temperatures, the use of a higher-melt index resin brings about other benefits, such as higher surface gloss and less shrinkage and warpage. Occasionally, changing to a higher melt index is the only means to fill a mold which cannot be filled under other conditions.

To figure the effect of a higher-flow resin on ram pressure and injection temperature, the following rules apply in most cases:

1) Assuming the same mold fill, cycle time, and injection temperature, ram pressure can be reduced by approximately 25% when the resin melt index is doubled.

2) Injection temperature can be reduced by roughly 70° F. when the resin melt index is doubled.

These rules of thumb are applied in Fig. 2, opposite, showing pressure and temperature curves for the 3.0 to 24.0 melt index range, starting at pressure p and temperature t for melt index 3.0. If for a particular job the pressure or temperature is known for any resin, the approximate values for other resins can easily be determined.

Molders who use a stiff-flow, or low-melt index resin for good end properties in large items may be running cylinder temperatures as high as 650 to 700° F. Good performance at these high temperatures requires that the resin be highly resistant to oxidation and the discoloration which may occur at these high temperatures.

Appearance of pieces

Surface gloss of the molded article is affected by resin properties, the condition of the mold, and molding conditions. The higher the melt index of the resin, the better the gloss of the molded part. Higher density also gives higher gloss.

However, a highly polished mold is one of the most important factors in obtaining high surface luster, and a warm mold will give a better gloss than a cold mold. Gating may also contribute to obtaining a high-gloss item: restrictive gating is known to produce higher gloss because it keeps the temperature high as the melt is injected into the mold.

Gloss generally improves with rising temperature, but each injection molding resin over the entire melt index range has its optimum injection temperature for surface gloss. However, even with all resins molded at their optimum temperatures, a higher melt-index resin will result in higher surface gloss.

To achieve high clarity, the main problem is to eliminate flow marks. This requires high injection temperature and low ram pressure. Clarity may also be improved by raising the mold temperature, especially in thinner wall sections when higher-melt index materials are used.

If an article can be made with a smaller cross section by using stiffer polyethylene, less resin will be used. Use of a stiffer resin of the same melt index will shorten the injection cycle by 15 to 30%—a gain in economy in addition to that obtained by the savings in material.

Shrinkage and warpage

Average linear shrinkage from the size of the mold to that of the

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[*] Data based on research conducted on U. S. I. Petrothene resins in the 0.915 to 0.929 density range.

[†] Mgr., Polymer Planning and Applications, U. S. Industrial Chemicals Co., 99 Park Ave., New York 16, N. Y.

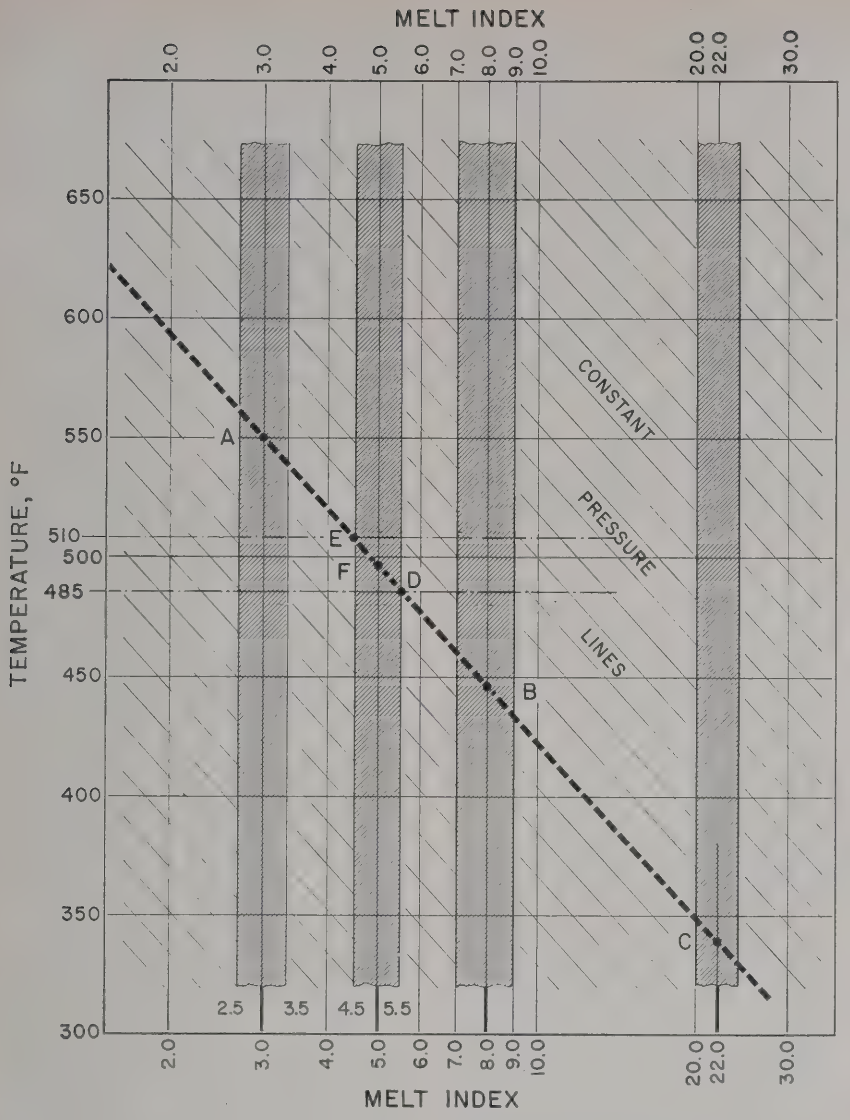


FIG. 1: Melt index of polyethylene vs injection temperature

final cooled article is 0.03 in./in. for low-density polyethylene. The injection molder can prevent excessive shrinking by controlling the operating conditions, designing the molded part and the mold with this problem in mind, and choosing the most suitable resin.

Shrinkage can be reduced by reducing the barrel temperature and running a cold mold, as well as by packing the mold more tightly. Longer dwell time in the mold before ejection is particularly useful wherever an inside dimension is critical, because longer dwell time can reduce shrinkage due to a cold-drawing effect.

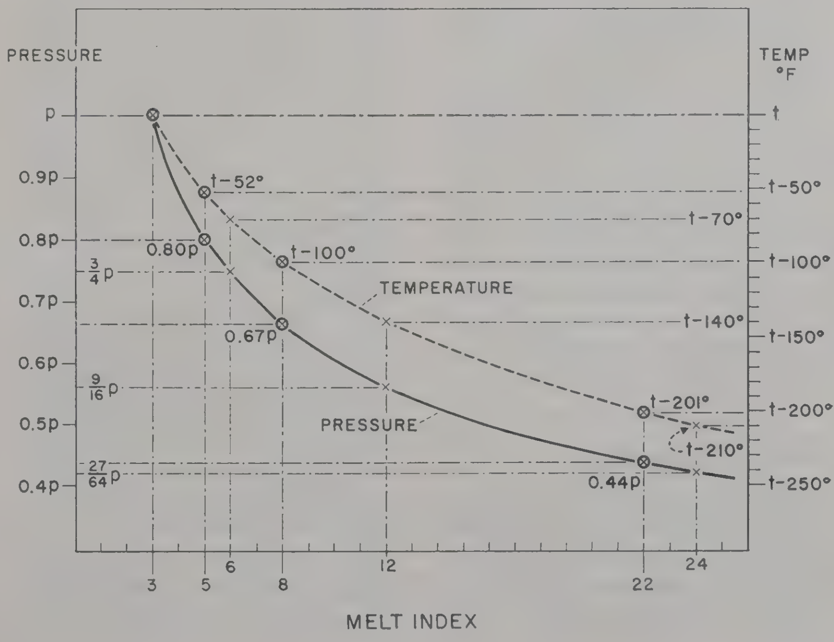
Longer dwell time to minimize shrinkage, however, means a longer injection cycle. Therefore, many molders would rather reduce shrinkage by running a cold mold.

Warpage results from nonuniform shrinkage. The resulting bending or twisting alters not only the dimensions but also the shape of the part. Warpage occurs mainly in large and flat articles. The problem for the molder—and it is often a difficult one—is to minimize the "locked-in" stresses generated in the mold by such operating conditions as excessive ram pressures, uneven cooling, or too low a melt temperature.

There is no single, clear-cut remedy for warpage. Use of high stock temperatures tends to kill the elastic memory of a resin and thus reduce the tendency to create stresses that may cause warping. Running a warm mold will allow stresses to relieve themselves before the melt "sets" or "freezes." In addition, greatest mold cooling should be concentrated around the gate where the resin temperature is highest. It should be minimized at the extremities of the part furthest away from the gating. With more cooling at the hottest points, the temperature of the entire part will be reduced more evenly, resulting in lower internal stresses.

Ram pressure should be held as low as possible to allow some of the internal stresses to be relieved before the part "freezes." But, of course, pressure must be kept high enough to avoid short shots. If the injection time is short, the mold fills before the material flowing to its extremities can cool too much. This gives the entire part a chance to cool at about the same rate which, in turn, tends to reduce subsequent warpage.

FIG. 2: Melt index vs ram pressure and molding temperature



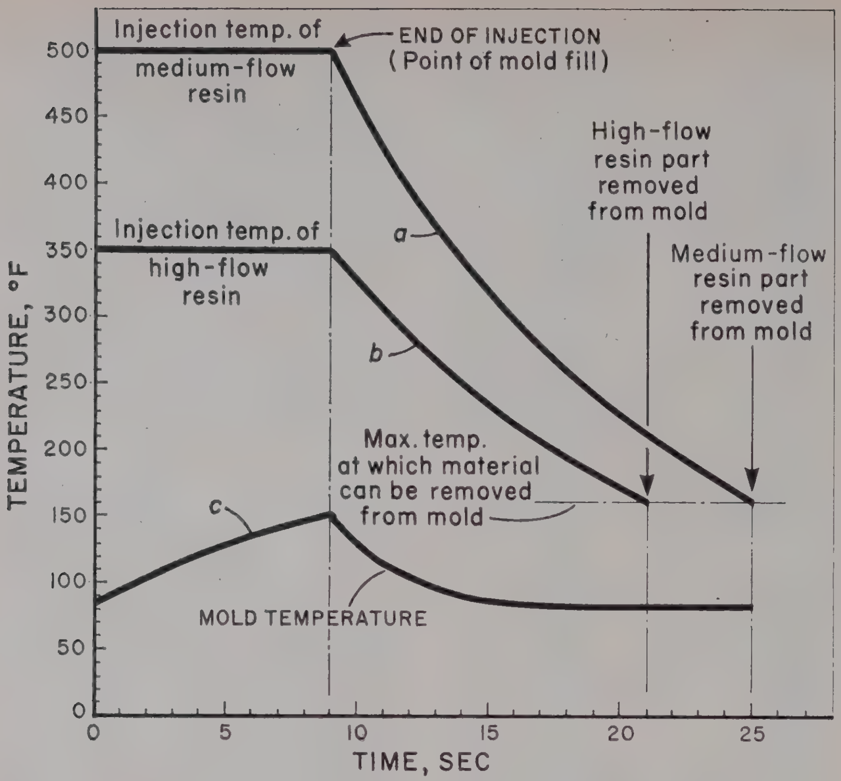


FIG. 3: Favorable effect on injection temperature and clamp time when a medium-flow polyethylene resin (curve A) is replaced by a high-flow resin (curve B), using the same mold temperature (curve C). Curves are illustrative only and do not describe the actual cooling pattern

Melt index range and resin uniformity are decisive in determining the temperature range for any molding job. For example, the permissible temperature range may be roughly from 485 to 510° F.—indicated by the horizontal lines through points D and E in Fig. 1, p. 607—which is a spread of 25° F. It can be seen that a slight variation of melt index is permissible: at 485° F., a resin with melt index 5.5 can be used (point D), while at 510° F., the melt index could be as low as 4.5 (point E). If the machine is set at 495° F. for an average melt index of 5.0 (point F), variations in melt index from as low as 4.5 to as high as 5.5 will still give proper mold fill with no flashing of the mold and no short shots. If, however, the melt index should vary below or above that range, flashing at a higher melt index or short shots at a lower one may be found to occur.

Temperature vs time

The effect on temperature and time of switching from a normal-flow to a high-flow resin is shown in Fig. 3, above, which plots temperatures against elapsed time during one clamp cycle. Curve *a* shows the temperatures of a typical medium-flow polyethylene (density 0.924, melt index 3.0) from the moment injection starts until the material has filled the mold and solidified and cooled enough for the finished end product to be ejected. Injected at a temperature of 500° F. the injection time for a typical job may be 9 sec., as shown. During this period, all the material flowing out of the barrel through the nozzle and the sprue and into the mold may have about the same temperature. When the mold is filled, the flow is stopped. In contact with a relatively cold mold, the resin will start cooling.

The mold temperature, as shown in curve *c*, may at first be about 80° F.; as the hot material fills the mold, it may rise to around 150° F., but as soon as the hot resin stops flowing into the mold, the cold water circulating through the mold will drop the mold temperature back to about 80° F. In contact with the colder mold, the injected polyethylene will cool at a fairly rapid rate, as indicated in the right branch of curve *a*. The resin must stay in the mold until a temperature of slightly above 150° F. is reached, when the part is stiff enough to be ejected. This temperature may be obtained after a total clamp period of 25 seconds.

Curve *b* shows the corresponding times and temperatures for a typical high-flow resin (density 0.924, melt index 22.0). It may require an injection temperature of only 350° F. This resin may also have filled the mold at the end of 9 sec., though it has probably heated it up much less than indicated by mold temperature curve c. Since it starts to cool from a much lower temperature than the lower-melt index resin, it may have dropped to the critical temperature of slightly above 150° F. about 4 sec. earlier than the normal-flow resin. This has reduced the clamp time from 25 to 21 seconds, a gain of 4 sec., or 16 percent. Such a significant reduction in clamp time will mean that a considerable increase in production may be obtained by employing a higher-flow resin.

Problems of high-flow resins

The use of high-flow resins, however, may confront the molder with several problems. One of these is bubbles. The high-melt index material flows very easily through the barrel at a comparatively low pressure which, however, may not be high enough to squeeze out all the air from around the plasticating cubes. Thus, air is entrapped in the molten resin and flows with it into the mold. Some of this entrapped air can be eliminated through increased mold venting.

The solution to this problem is the installation of back-pressure plates at the end of the barrel between the torpedo and the nozzle. Back pressure on the melt will in most cases squeeze all the air out from between the plasticating cubes and produce a bubble-free molded item. The back-pressure plate is drilled with small sized holes.

Faster cycles

Use of higher-density resins within the low-density range will result in molded articles that can take higher service temperature without distortion and may also reduce cycle time because their greater stiffness and higher heat softening points permit parts to be ejected at higher temperatures. Cycle times can thus be reduced by 15 to 30 percent. The amount of the reduction depends on the size and shape of the molded article, the speed of the machine, and the agility of the operator. A general rule of thumb is to figure a cycle time of 2 to 3 sec./oz. of injected resin. An average 8-oz. shot may require 16 to 24 sec. when an 0.916-density resin is used. Switching to an 0.924-density resin will reduce the cycle time by 2 to 8 seconds. However, the shape of the item being molded and mold construction are major factors in determining cycle time. The molding cycle may also be shortened, production facilitated, and shot-to-shot uniformity increased by first heating the resin in a preplasticizer.

INJECTION MOLDING: Medium-density polyethylene

By C. S. Imig*

By A.S.T.M. definition, medium-density polyethylenes consist of those resins having densities between 0.926 and 0.940 g.m./cc. They display improved stiffness, gloss, and temperature resistance with no loss in toughness, as compared with low-density resins.

A very sharp change in physical properties is found in the 0.926 to 0.940 range. At the low end are the popular high-melt-index resins with their exceptionally good molding qualities while at the higher end the melt indexes available are limited to the lower range. Important properties such as brittleness are affected by both melt index and density; extreme care must therefore be taken to balance these two properties so that a usable resin is obtained.

No special handling is required with intermediate-density polyethylene. The resin may be used as received unless dry color is to be added. Then tumbling with the pigment for 10 to 20 min. is required.

Mold design

Proper mold design for intermediate-density polyethylenes follows the same line as for other polyethylenes. Runners should be generous so that fully plasticated material is supplied to the cavities. Gates may vary in size from 0.025 to 0.250 in., depending on the part being molded. In general, gates should be kept small, consistent with molding void- or sink-free parts, avoiding jetting, and avoiding the need for excessive temperatures. The gate land lengths should likewise be kept short. The use of pin-point gates greatly improves color dispersion when dry-coloring.

Particular attention must be paid to ejection of the part, just as with low-density polyethylenes, because of the inherent flexibility of the materials. Ejector pins should be large and draft angles generous. Generous undercuts may be used to provide for positive placement of the part on either the front or back half of the mold, prior to final ejection, as may be desired.

Highly polished mold surfaces make ejection more difficult, particularly from cores, although they do improve surface finish. Liquid honing, where appearance permits, is useful in assisting ejection, as is the use of air blasts. Large water lines (½ in. where possible) should be employed, while taking care to design maximum, efficient cooling into the mold. There has never been a mold built with too much cooling. Particular attention should be paid to providing positive clamping of the mold when molding large-area sections.

Equipment: No special equipment is required for molding intermediate-density polyethylenes. These materials have performed satisfactorily on all types of injection presses. Since it is more difficult to obtain good color dispersion with these intermediate-density resins than with the low-density materials, it is often desirable to employ dispersion nozzles, although pin-point gating has proved more effective in providing good color dispersion—when it can be used.

Molding characteristics

It is impossible to set up a list of molding conditions which cover all cases. However, the tables of molding characteristics, p. 623, can be considered as a rough guide in determining where to start.

Generally, melt index can be considered a good indication of the flow of a particular resin. Lower temperatures, lower pressures, faster cycles, better gloss, and less shrinkage are associated with higher melt index resins, while maximum physical properties require use of lower melt index resins. These low melt index resins are quite stiff flowing and often require molding temperatures as high as 600 to 650° F. More care than usual must be exercised in these cases to avoid degradation of the polymer whenever the cycle is disrupted. The material must be kept moving through the machine when operating at these temperatures or else the machine must be effectively purged to avoid producing discolored and brittle parts.

The good molding practice of purging the heating cylinder is too often neglected in shops molding polyethylene. In order to avoid the excessive deposition of carbonized material on the spreader and cylinder wall, regular purging of the machine is recommended. This does not completely eliminate the carbonization, but does control the amount of deposits, so that black specks in the parts may be held under control. A machine should be purged at least every time it is started up, shut down, or allowed to stand idle any length of time. In starting up, as soon as the cylinder is hot enough to allow material to start flowing through it (about 300° F.) the machine should be purged until operating temperatures are reached. When shutting down, the machine should be purged until the temperatures have reached 400 to 300° F.

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*Sr. Staff Member, Plastics Sales Service Laboratory, Spencer Chemical Co.

INJECTION MOLDING: High-density polyethylenes

By J. N. Scott and J. V. Smith*

Successful molding of high-density polyethylene in a wide variety of applications, using most types of conventional equipment, has been largely due to rapid development of technology in mold construction, part design, and operating conditions. Molders have found that the good molding practices desirable for many other thermoplastics are often essential for both quality and rapid production of high-density polyethylenes. For example, maximum uniformity of pressure and cooling rate of resin in the mold are particularly important with these materials because of the direct relationship of shrinkage to packing and cooling rate. Attention to these fundamentals will generally insure quality parts, free from "molded-in" strain, that take full advantage of these resins' inherent characteristics. Conversely, variations in either cooling rate or the forcing of excessive resin into the mold can result in unacceptable parts from the standpoint of warpage, strength, or "molded-in" strain.

In order to achieve optimum results for any given operation with high-density polyethylene, consideration should be given to the several factors discussed in the following sections.

Resin type

High-density polyethylenes are now available in a variety of grades differing mainly in flow characteristics, toughness, and resistance to long term stress cracking. The proper choice of grade for a given job is essential to satisfactory production and product performance. This can usually be made by considering that maximum density gives maximum rigidity and impact strength for a given melt index, while maximum environmental stress cracking resistance is obtained in the lower density range. Flow characteristics or melt index are, of course, important in the ease of filling the mold but also have a direct bearing on surface appearance and toughness. Industrial parts demanding a high degree of toughness should be molded from low melt index resins. Intermediate flow resins allow high production rates and give better surface gloss and are very satisfactory for housewares and items where extreme toughness is not as important. Higher flow resins are required for molding extremely thin section parts and possess toughness adequate for most disposable packages, etc. Although these basic relationships apply generally, it is usually advisable to consult material suppliers for resins best suited to a particular application.

Molding machine requirements

A variety of machines can be successfully used with these materials. For a specific job, however, the equipment to be used should be selected on the basis of plasticating capacity, clamp pressure, and injection pressure and speed. High production rates are dependent on adequate plasticating capacity for high-density polyethylene. In order to achieve maximum production rates, the equipment should furnish the estimated required volume of material at a temperature no less than 80% of the indicated cylinder temperature. The published plasticating rates of some machines do not take this relationship into consideration.

In addition to allowing fast production rates, high injection pressure and speed are sometimes also necessary to obtain quality parts. A fast fill will allow more uniform cooling, reduce any tendencies to warp, and minimize "molded-in" strain. These factors are particularly important for thin wall or "big ticket" items. Experience shows that an approximate 2000 p.s.i. increase in material pressure will give greater increase in flow than a combination of other available variables. In selecting a machine for molding high-density polyethylene, clamp pressures of three to four tons per square inch of projected part area are usually desirable. The exact clamp pressure will, of course, vary depending on the ease of fill of the mold used.

Mold design

Two plate, three plate, hot-runner and insulated-runner molds[1] all have applications in molding high-density polyethylene. The insulated-runner type mold is rapidly gaining in popularity because of relatively low cost, shorter cycles, less scrap, and ease of "line-out." Conventional two plate and three plate molds—aside from gating and cooling systems—require little special design for these resins. With hot-runner systems, care must be exercised to prevent excessive heating of the cavity in the gate area. This frequently presents a problem of balancing heat in the runner system with adequate cooling of the cavity surface. With all types of molds, runner length should be kept as short as possible and should be large enough in diameter to allow rapid filling with minimum temperature and pressure. Gates should be just large enough to allow rapid fill and prevent jetting. With edge-gated sections where resin does not impinge on cavity surface, the gate diameter must be from 60 to 80% of the section thickness.

Perhaps the most important mold design feature to be considered is the temperature control system. This importance can best be realized by considering the large differences in shrinkage that are obtainable by variations in mold temperatures (from 0.015 to 0.045 in./in. depending on geometry and thickness). In addition to minimizing warpage tendencies, adequate cooling systems are generally important from the standpoint of obtaining maximum toughness and production rates. Separate water channels should be located near gate areas, ribs, large flat sections, and differences in wall thickness.

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*Phillips Chemical Co., Bartlesville, Okla.

[1] Scott, J. N., Peters, D. L., and Boeke, P. J., "Insulated runner systems for injection molding," S.P.E. Technical Papers, Vol. V, No. 66 (Fifteenth ANTEC Preprints).

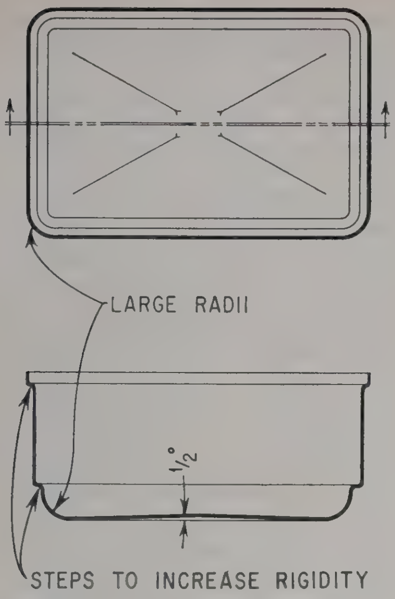

FIG. 1: Design features which allow a certain amount of shrinkage variation without danger of part distortion.

Cooling channels should be concentrated in the gate area to balance the tendency toward heat build-up and slow cooling at this point.

Bubbler or baffle tube channels are usually effective for cooling gate areas of cores 2 in. or more in length. If the projected area of the part is large, additional channels should be incorporated near the sides of the core. While water channeling should be concentrated in the gate area, it should also allow for cooling the entire surface of the part as uniformly as possible. Channels near the gate and those controlling mold temperature near the extremity should always be separate to allow operation at different temperatures. Where injection speed is low or part size is large, it is often necessary to operate the periphery from 20 to 50° higher than the gate section.

Other mold design features to be considered are adequate venting, proper tapers, mold surface, and proper ejection system. Tapers as low as ¼° per side are satisfactory where mold surfaces are smooth and the ejection system can force the part completely from the core without distortion. An indication of the ease of ejecting high-density polyethylene parts is the success that has been achieved even with slight reverse tapers where high air pressure can be used to remove the part while it is still hot.

Conventional types of ejection are satisfactory with these materials. Where ejection pins are used, the choice of as large a diameter as practical will minimize distortion of parts and will allow faster ejection. Combinations of air and stripper ring ejection are effective and are increasing in popularity for deep draw items.

Mold surface finishes are extremely important for items that must exhibit an attractive appearance. Generally, the high-density polyethylenes will accurately reproduce the mold surface. Where a high degree of gloss is desirable, the mold should be highly polished. Where an item with maximum scuff resistance is required, a coarse texture should be considered.

Molding conditions

To achieve maximum production rates, low cylinder and mold temperatures are usually preferred. Mold temperatures should be as low as possible without causing flow marks and care must be exercised to avoid temperature build-up at high production rates.

Cylinder temperatures should usually be 20 to 50° higher than the minimum required to fill. The exact temperature will, of course, depend on resin flow characteristics and the size and thickness of the part to be produced. For relatively thick sections (over ¼ in.) low cylinder temperatures in the range of 275 to 300° F. give best results. Temperatures from 300 to 400° F. are usually desirable for sections from ⅛ to ¼ inch. For sections less than 0.030 in., temperatures from 400 to 575° F. are often necessary.

Of greatest importance in selecting molding conditions is the use of low mold temperatures and proper feed and injection time settings. Severe packing of sections less than ¼ in. thick or mold temperatures that are excessive must be avoided.

Part design

Proper consideration in the design of high-density polyethylene parts can increase rigidity, result in improved esthetic qualities, and can often obviate warpage problems. Figure 1 illustrates design features for a box-like item that will even allow a certain degree of shrinkage variation without part distortion. The large radii at the corners and the steps in the sides of the box add considerable rigidity. The slight crown or pyramid section in the bottom of the box breaks up what would normally be a flat area and eliminates any distortion in the finished part.

INJECTION MOLDING: Polycarbonate

Polycarbonate resin has been successfully molded in molds that were designed for nylon, acrylic, polystyrene, cellulosics, and others. However, consideration must be given to differences in mold shrinkage and flow characteristics between PC and other resins. The following mold characteristics are helpful in obtaining best results.

1) *Heated molds:* While some parts can be molded satisfactorily in room-temperature molds, heated molds usually give best results. For most parts, mold temperatures of 175 to 200° F. give good results. Both front and rear parts of the mold should be heated. Molds having large areas, thin sections, or complex shapes, or multiple-cavity molds having long runners may require higher mold temperatures. Some molds have filled best at temperatures of 230 to 250° F. Coring designed to keep the runners as hot as possible has been found beneficial in molding PC. Parts will eject from the mold at temperatures up to 250° F., or even higher for thin-walled parts.

2) *Sprues and runners:* Sprues of standard design perform satisfactorily. For improved flow, however, an extended nozzle with heater band used in conjunction with a short sprue bushing is suggested. An adequate cold-slug well should be provided, though cold slug can be minimized by use

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Adapted from "Working with polycarbonate resin," by E. F. Fiedler, W. F. Christopher, and T. R. Calkins, MODERN PLASTICS 36, 115 (April 1959).

of a heated nozzle with cut off. Large-diameter runners, full-round and as short as possible, with a minimum number of right-angle turns, are recommended.

3) *Gating:* Full-round, large-diameter gates give good results, as do also large rectangular gates. Gate lands should be as short as possible. Tab gating gives good results and sometimes helps overcome splay when gating into thin sections. The gate to the tab should be large. Fan or fish-tail type gates also give good results.

4) *Inserts:* PC molds well around inserts and, because of its unusual toughness, holds inserts firmly. It is necessary, however, that sufficient plastic be molded around the insert to distribute the strain set up in the material by the differential thermal shrinkage of metal and plastic.

5) *Mold shrinkage:* Mold shrinkage of PC is 5 to 7 mils/in. and is predictable to rather close tolerances. Shrinkage is about the same both in the direction of flow and across the direction of flow. Molds should be designed to 6 mils/in. shrinkage. Post-molding shrinkage has not been observed in PC parts. Cycle, as it affects "packing" in the mold, can influence dimensions slightly.

6) *Mold lubrication:* For mold lubrication, an occasional light dusting with zinc stearate is suggested. Silicone spray is also effective as a lubricant but may result in poor surface finish of the part. Minimum use of lubricant is desirable and any tendency of parts to stick in the mold may better be eliminated by appropriate adjustment of temperatures, pressure, or cycle, or in some cases by polishing the mold.

7) *Mold surface:* Either polished-steel or chrome-plated surfaces are recommended.

Molding temperature

PC resin has a broad plastic range and good thermal stability at usual molding temperatures—from 525 to 625° F. Where adequate mold heat is available, few parts require cylinder temperatures above 600° F. A heated nozzle usually improves moldability and surface finish.

Cylinder temperatures: Best results are usually obtained by keeping the rear cylinder temperatures higher than the front cylinder temperatures. On machines having three heating zones the following conditions are typical:

Rear °F.	Middle °F.	Front °F.
600	575	575
575	575	550

On machines having two heating zones, the following conditions are typical:

Rear °F.	Front °F.
600	575
575	550

Nozzle temperatures: A heated nozzle is desirable when molding PC, and the nozzle temperature should be equal to the front cylinder temperature for best results. If drooling occurs, nozzle temperature may be lowered. On machines not having a separate nozzle-heat control, good results have been obtained by controlling the nozzle-heater band with the front-cylinder-zone thermocouple. Nozzles equipped with automatic cut-off have been run at temperatures above the front cylinder temperature with good results.

Overheating: PC resin shows outstanding resistance to thermal degradation. However, overheating can result from excessive dwell time in the cylinder at high temperatures. Excessive color change to dark yellow may indicate that the cylinder temperature is too high or that the nozzle temperature is too high if it is higher than the front cylinder. When darkening or color change is found in molded parts, such parts should be tested for toughness. If they show any brittleness, this is an indication that degradation has occurred. Such parts should be scrapped and the cylinder purged. Resin that has picked up moisture can be degraded at temperatures and dwell times that would leave well-dried resin unaffected. So an apparent problem of overheating may be a problem of moisture-pick-up.

Nozzles

The conventional injection nozzle with tapered bore can be used for molding PC, but is less satisfactory than some of the newer types of nozzles. Also, it is frequently difficult to fit a heater band to injection nozzles of this type. Because of the high melt viscosity of PC, a nozzle design that will offer minimum resistance to plastic flow and transmit maximum pressure to the mold cavity gives best results.

A nozzle with a constant-diameter bore, a rather sharp radius to the orifice, and short land is recommended. A reverse taper on the land facilitates sprue removal. This recommended nozzle can be easily heated, and extended nozzles of this type can be used with molds designed with short sprue bushings to increase plastic flow. Nozzles with screens should not be used.

To eliminate drooling of PC at high nozzle temperatures, nozzles equipped with an automatic cut-off device have been found helpful. At normal molding temperatures, drooling is not a problem with PC and, should it occur, can generally be controlled by dropping the nozzle temperature 10 to 25° F. Should drooling continue, the problem may be one of moisture pick-up resulting in degradation of the resin, and parts should be tested for toughness.

Before molding PC, the cylinder should be thoroughly purged. A purge with crystal polystyrene followed by a PC purge is recommended as both an economical and efficient procedure. It is suggested that nylon resins not be purged directly with PC. After molding with PC, an immediate purge with crystal polystyrene is suggested if the machine is next to be used for molding a material other than PC. Occasional purging is recommended after shutdown while the cylinder is cooling, particularly after operating at high cylinder and nozzle temperatures.

As with other resins, optimum cycle requires a quick fill, hold time just adequate to allow gates to freeze, and a short setting period. For most molded parts, the highest possible ram speed has been found desirable, for thick as well as for thin sections.

PC moldings, like those of other thermoplastics, show varying degrees of molded-in stress, depending on molding conditions. Molding at the conditions recommended above will usually keep the stresses down to the level at which performance of the parts is not adversely affected. However, if internal stresses are too high for the application, they may be partially relieved in parts less than ⅛ in. thick by heating them overnight in an oven at 250 to 275° F. For thicker sections, annealing for at least 24 hr. is suggested. Caution: heating above 275° F. may cause distortion and shrinkage.

Polycarbonate must be kept dry before and during molding, since it will absorb moisture from normal plant atmospheres. To this end it is shipped dry in sealed 25-lb. tins. The best handling procedure in the molding or extrusion plant is as follows: Heat the unopened can and its contents to 250° F., pour the hot pellets into the machine hopper, and keep the air over the pellets at 250° F. with a hopper drier, preferably one of the dehumidifying type. Circulating air through the pellets at some temperature less than 250° F. is more likely to increase than reduce water absorption by the molding material.

Where this procedure can't be followed, the following precautions are helpful: 1) never open a can that has just been taken from a cold storage area; 2) if powder is fed at room temperature, keep it out of contact with room air—either use a dehumidifying-type hopper drier or simply cover the machine hopper.

Molding powder that has been exposed to moisture, and all reground material, must be redried. This can be accomplished by spreading the pellets in trays to a depth of 1 in. or less and heating them at 230° F. for at least four hours in a dehumidifying oven, or at 260° F. in an oven that is not equipped with a dehumidifier. Since PC pellets tend to pick up dust by static electricity, trays should be carefully cleaned before they are loaded.

INJECTION MOLDING: Polypropylene

By Russell D. Hanna* and John Y. Lomax*

The design of polypropylene products should aim at minimizing weld lines, sinks, and air traps. Radii should be generous. Uniform wall sections are best, and changes in thickness should occur as gradually as possible. Because of the material's high mold shrinkage—typical of polyolefins—and the differential shrinkage among sections of different thickness, heavy ribs, bosses, and fillets should be avoided or minimized by rounding into the walls and increasing the wall thickness slightly in those areas. Typical observed shrinkages, depending on conditions and part design, have been: 10 to 17 mils/in. in sections 62 mils thick, up to 21 mils/in. for quarter-inch sections. Once on cycle with a given molding, the piece-to-piece variations in shrinkages are negligible.

Where greater rigidity is needed, channels and curved walls are preferable to ribs. Curved lines also often improve the product's appearance.

Mold construction

The principles of mold design valid for most thermoplastics are just as important to the successful molding of polypropylene. It has been molded in two- and three-plate molds, molds with hot runners, no runners, and valve gates—any basic mold construction can be used.

Full-round runners are best, trapezoidal runners being the best substitute when the entire runner section must be in one plate because of cam or slide actions. Runner surfaces should be left unpolished after fine machining: a somewhat rough surface keeps the cooled skin from sloughing into the cavity and marring the surface finish of the piece. Oversize runners—¼ to ⅜ in. in diameter—stepped down 1/16 in. at each branch, along with substantial over-runs at each turn to serve as cold-slug wells, will help prevent problems in filling most molds.

Gating

Gate size should be the minimum needed to permit filling; for most small, multi-cavity work this will be 30 to 60 mils. Round gates are recommended wherever applicable, and they should be so located that the melt impinges against a mold surface to build up a smooth flow of melt into the cavity, preventing jetting and "worming." Gate lands should be no more than 40 mils long. In filling heavy sections and pieces requiring long flow, gates may have to be as large as 90 mils or even larger in diameter to prevent sinks and voids.

Many articles, particularly large moldings, are best gated perpendicularly into one of the large areas (back gating). This gives uniform and symmetrical fill and minimizes flow distance.

Location of the gate is an individual problem with every part. The best procedure is to visualize the flow from various locations, then choose the one that will minimize jetting, sink marks, weld lines, and air traps, based on past experience with such faults. If possible, weld lines—often weak—should form along lines that will be lightly stressed in service.

Multiple gating may be necessary to reduce flow distances, improve flow patterns, and locate welds along lines of low stress.

Warping

Almost everyone who has molded polyolefins has faced the problem of a center-back-gated tray, box, or plate distorting unsymmetrically over the flat surface into a shape known as a "figure 8" or "saddle warp." This is a result of the radial shrinkage being greater than the circumferential shrinkage, which is a consequence of the flow pattern during filling.

These shrinkages can be equalized, at least in part, if the thickness of the flat section is increased slightly with increasing distance from the gate, making the section heaviest at the remotest points. The heavier sec-

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* Hercules Powder Co., Parlin, N.J.

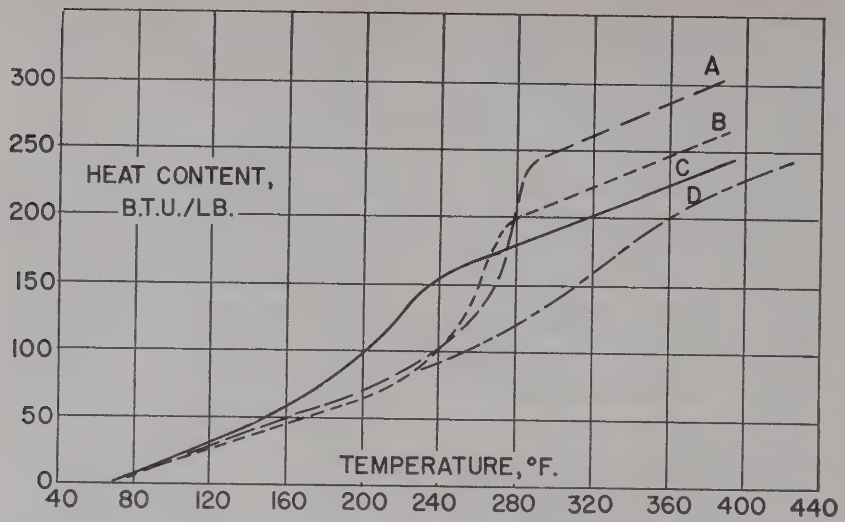

FIG. 1: Heat content, above 68° F., for four polyolefins. Curve A: polyethylene of 0.96 density; B, Hi-fax polyethylene of 0.945 density; C, low-density polyethylene; D, polypropylene

tions will tend to shrink more and in a circumferential direction, counteracting the reverse effect of the flow pattern.

Stripper plate ejection is preferable to ejector pins, since in the former the pressure is applied in a more uniform matter and is less likely to cause distortion. Ejector pins, if used, should be as big as possible and should work against those sections of the molding that provide greatest stiffness and strength. Deep-draw parts are often ejected with compressed air; however, if they must be ejected mechanically, a vacuum-breaker valve should be used to prevent distortion. Long cores should be tapered about 1 degree.

Mold temperature

An important requirement for successful polyolefin molding is closely controlled, graduated mold cooling. This requires plenty of cooling channels, located in such a way as to concentrate the cooling in the gate area and thin it out at the extremities. Graded cooling helps offset the differences in temperature and set-up time between the material that first enters the mold and that which enters last. Good mold temperature control has made it possible to mold acceptable polypropylene parts in molds designed for the shrinkages of other plastics.

With thicker sections, higher mold temperatures are advisable to prevent formation of shrinkage voids in the finished molded piece.

Opening the gate to permit packing during cooling also helps prevent voids. A word of caution in this connection: before lengthening the cooling time to prevent voids, one should examine carefully the need to prevent the voids. These usually occur in the soft centers of thick sections and consistently in the same vicinity inside the piece. Where the principal loads on the piece are tensile, the load-bearing capacity will be reduced in proportion to the reduction of cross-section. On the other hand, if the piece is to be subjected to bending and/or twisting loads, surprisingly large centrally-located voids will never be noticed, strengthwise. Since thick polypropylene sections are opaque, the voids cannot be seen. Of course, voids may lead to unsightly sinks that must be eliminated.

In sections under about 60 mils, the transparency of polypropylene (in percentage of light passed per mil of thickness) increases with the rapidity of cooling, and shock cooling may be warranted in some applications.

To design the cooling system properly, one must know how much heat is to be removed. This can be calculated from the piece weight, the drop in temperature to be achieved, and the change in enthalpy, or heat content, of the resin between those temperatures. This property of the resin is plotted in the graph of Fig. 1, left. (Naturally, the heat content is also involved when doing any calculating of heat *inputs* to heating cylinders.)

Above 380° F., polypropylene exhibits the rapid exponential increase in fluidity with temperature characteristic of other polyolefins. In practical terms, this rapid rate of change of flow limits the molding range of *stock* temperatures to between 450 and 525° F. At lower temperatures it will be difficult to fill the mold; at higher temperatures, on the other hand, there may be trouble with flashing.

Cylinder capacity down

Polypropylene has been stabilized against thermal degradation, but yields no corrosive products even if accidentally decomposed. Also, it does not absorb water, so no special drying or handling techniques are needed. No special materials are required in machine construction. Dry coloring is possible if the colorants used can withstand the higher processing temperatures involved. Suggested start-up molding conditions are given in Table I, p. 615.

Polypropylene has the highest specific volume of all the present commercial thermoplastics, and its specific volume rises rapidly with rising temperature. Compared with polystyrene, its specific heat—rate of increase in heat content with temperature—is also high. These two factors combine to reduce the shooting and plasticating capacities of cylinders rated in terms of polystyrene. In a recent evaluation, using the method of rating plasticating capacity proposed by the S.P.I., a cylinder which was rated at 42 lb./hr. of G-P polystyrene would only melt 27.5 lb./hr. of polypropylene. This is not as serious as it sounds, since a smaller weight of polypropylene is needed to fill a given cavity than of polystyrene, and the effective reduction in volumetric plasticating capacity is about 21% rather than 33%. However, the difference is large enough to deserve consideration in choosing a machine for a given job.

Like other thermoplastics, polypropylene is best molded at high rates of filling, i.e., at high ram

TABLE I: Suggested molding conditions for polypropylene

	Thickness of section		
	Less than ⅛ in.	*⅛ to ¼ in.*	*Over ¼ in.*
Cylinder temperatures[a], °F.			
Rear	475-600	450-525	450-525
Center	475-600	450-525	450-525
Front	425-550	400-475	400-475
Nozzle	400-500	400-500	400-500
Melt temperature, °F.	450-525	450-525	450-525
Mold surface temp., °F.	60-180	60-220	100-220
Ram pressure, p.s.i.			
Standard cylinder	10,000-30,000	8,000-30,000	8,000-30,000
Preplasticator	8,000-30,000	6,000-30,000	6,000-30,000
Approximate cycle, sec.			
Including mold open	15	30	60
Ram forward time	5	10	15

[a] These are recommended start-up temperatures, and final operating temperatures may be higher, depending on the application, machine, and cycle. The aim should be to reach a *melt* temperature within the recommended range that gives satisfactory operation.

speeds and pressures. Whenever possible, full booster and high injection-ram speeds should be used to build up and maintain pressure at the extremities of the mold. The resin is also well suited to preplasticating machines, precompressed molding, and other means of achieving high pressure in the mold.

Mold temperatures can be somewhat lower for polypropylene than for many other polymers. Good surface finish can usually be achieved at mold temperatures of 60 to 100° F. if the melt temperature is reasonably high and the effective ram pressure is sufficient to insure smooth flow into the cavity. Mold shrinkage will decrease with lower cylinder and mold temperatures, with higher injection pressure, and longer ram-forward time.

INJECTION MOLDING: Polystyrene

By L. W. Meyer*

Good mold design and construction are essential to successful molding of polystyrene.

Materials of construction: Low-carbon steel, with small concentrations of alloying elements, are the principal materials for hobbed molds. These steels are case-hardened by carburizing, which gives them relatively soft interiors. Increasing amounts of alloying elements give deeper hardening but reduce hobbability.

The decision to hob a mold is generally made when the mold requires intricate cavity design. Such design is easier to machine in a male hob than in a female cavity block. Hobbing is also very satisfactory for multiple-cavity molds, and for molds designed with two identical halves that must match.

With high-carbon alloy steels, it is not necessary to carburize to obtain hardness. The alloying elements modify the hardenability and permit deeper hardening of the metal mold parts with oil or air quenching. For large-area molds, deeper hardening is necessary to minimize permanent deformation of the cavity.

Unfortunately, larger billets usually cannot be forged to uniform stress throughout; the machining destroys the equilibrium of these stresses. To minimize these effects it is common practice to machine the billet to within about ⅛ in. of the finished dimension and then stress-relieve before final machining. The annealing furnace should fluctuate 50 to 100° F. in the stress-relieving temperature range to provide mechanical stress due to thermal expansion and contraction. By mechanical working, stresses are relieved more thoroughly than they would be at constant temperatures.

To offset the risk of warpage during hardening, prehardened steel is often employed. However, it is neither soft enough to machine easily nor hard enough to be polished to a high luster.

Hardness is also an indirect measure of yield strength. Therefore, harder molds are less likely to become permanently set due to deflection under load. Prehardened steel usually has sufficient yield strength for most mold requirements, but it is not hard enough to resist concentrated stresses which result in abrasion or pitting.

Hardness is not, however, a measure of stiffness. Both dead-soft hobbing steel and the hardest hob metal have a modulus of stiffness of 30,000,000 p.s.i. Each will deform by an equal amount with a given load, below the yield point. Beryllium copper, on the other hand, has a stiffness modulus of 20,000,000 p.s.i. and thus will deform one and one-half times as much as steel for a given stress. It should therefore not be used except for short-run, noncritical items. Beryllium copper does, however, have much better cooling characteristics than steel and is often used to transfer heat in small-diameter steel core pins.

Mold and part design

Product design: Proper product design means better control of the plastic flow within the mold, resulting in improved molding operations and less defective parts. Section-thickness variations determine the manner in which the plastic fills the cavity. Large variations in section thickness may result in air or gas traps, nonuniform surface finish, sinks, weak weld lines, and other problems—*if* the plastic flow is not controlled in such a manner as to allow the mold to be filled uniformly. For these reasons, section thickness should not vary more than ± 20 percent.

Bosses and ribs, while necessary in many designs, often upset the balanced flow pattern. Thermal stresses may be caused by unequal cooling rate due to the varying section thickness and sink marks opposite them are likely to occur. To minimize problems of this type as much as possible, it is desirable to keep the width of these sections smaller than the section thickness of the part to which they are attached. Depth should not exceed twice the width. Exceptions, of course, are often necessary. Sharp corners should always be avoided through use of fillets and radii. They should not, however, be excessive.

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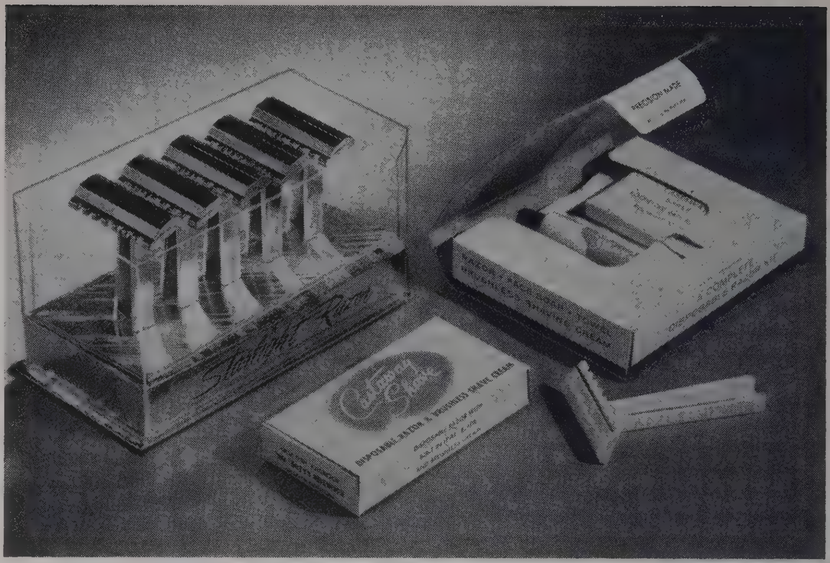
* The Dow Chemical Co., Midland, Mich.

Mold venting: Proper venting is also necessary. Vents should be spaced 1 to 2 in. apart. To prevent flashing or burring, the depth of the vent at the parting line should not exceed 2 mils with land length of 20 to 30 mils and relieved from behind to greater depths to eliminate air resistance.

Sprues and runners: Sprues should have a base opening which is approximately 1/16 in. larger in diameter than the nozzle orifice opening. Base diameters between 7/32 and 9/32 in. with a 1/2 in./ft. taper are adequate for most applications.

Full round runners are preferred over other types. For small pieces and short runner systems, a 3/16-in. dia. runner will be sufficient. The 1/4-in. dia. runner is usually recommended for most molds, although for extremely large pieces 5/16- or 3/8-in. dia. may be necessary. Trapezoidal shapes are also acceptable, but somewhat less desirable than the round type. Sizes should be in the same range as the round runner. Runner systems should be balanced if uniform filling of multiple (identical) cavity molds is to be expected. This can be accomplished only if all the gates are equidistant from the sprue and if all the runners are the same size. (This subject was discussed in detail in MODERN PLASTICS Oct., 1956, p. 166.)

Gating: Restricted, or pin-point, gates are most common, although other types such as the sprue and submarine are also employed. As a rule of thumb, the thickness for gates should be from 40 to 60% of the section thickness of the part to which they are attached. Widths should be 1/16 in. less than the runner diameter, with land lengths as small as practical. Pinpoints with some taper for easy release generally range between 30 and 45 mils in diameter.



DISPOSABLE RAZOR, injection molded of polystyrene, has built-in blade, is inexpensive enough to be used once and then thrown away. It is marketed in single packs, with shave cream; in decorative five-unit sets; and in sanitized envelopes for pre-operative use in hospitals

Molding characteristics

Drying: Polystyrene is not a hygroscopic material and therefore drying is seldom necessary. Condensed moisture on the surface of the molding pellets may, however, cause "blisters" upon molding. When such conditions exist, drying will be necessary. Preheating, which is not necessary for drying purposes, may be of considerable benefit to the molding operation by assisting the injection cylinder to operate at lower temperatures. This may also result in a definite increase in production rates, particularly on operations where the heating capacity of the cylinder is a limiting factor. Heating times in the range of 45 to 90 min. at temperatures of 170 to 180° F. are recommended for granular layers approximately 3/4 in. deep in oven trays.

Molding conditions: Polystyrene can readily be molded in standard injection molding equipment. Exact molding conditions (temperature, pressure, and cycle time) depend on the individual machine being used, and the size and geometry of the object being molded. Typical values normally encountered are tabulated in Table on p. 626. Top safe temperature for a 20-min. exposure is approximately 500° F. While such values are helpful to serve as starting points, the molder must determine the best operating conditions for the particular molding operation.

In attempting to establish the optimum molding condition from a particular starting point, it becomes important to understand the demands that mold section thickness place on molding conditions.

Mold section thickness

Thin sections (below 50 mils): Speed of injection is of first importance. Cooling effects while filling are very large, resulting in a rapid increase in plastic viscosity. For this reason, plastic pressure requirements also become extremely high. To help offset both the cooling on filling effects and pressure requirements, higher cylinder temperatures must be employed if fast flow is to be maintained. Mold cooling time is of much lesser importance. A layer 30 mils thick will set up in approximately 3.5 seconds. Orientational stress is the principal type of induced stress. As the injection speed increases and the gate size decreases, the greater will be the flow-orientation in the part. To ease this problem the part should never be molded faster than necessary and the gate should never be smaller than necessary. Only through an optimum balance between these two variables will this problem be minimized.

Medium sections (50 to 100 mils): Speed of fill is not as critical since cooling on filling is considerably reduced. This means lower plastic temperature and pressures are possible. Mold temperatures should be high enough to prevent undue orientational and thermal stress but low enough to keep mold-closed time to a minimum. Packing stresses are also undesirable and generally cannot be tolerated. Holding pressures should therefore be lower than the injection pressure. Restricted gates which freeze quickly are most helpful in eliminating packing problems.

Thick sections (over 100 mils): Principal problems with this type of molded article are sinks and vacuum bubbles caused by thermal-shrinkage stresses and long cooling periods. A cooling time of 100 sec. may be required for parts 0.160-in. thick. To control these problems as much as possible, a number of things can be done. Cylinder temperatures as low as possible should be used, with the plastic temperature as uniform as possible. Preheating the granules prior to molding is of considerable aid in achieving uniform plastic temperature. This generally allows a lower cylinder temperature to be employed. Packing can usually be tolerated to a greater degree in heavy section molds. For these reasons, large gates which do not freeze quickly are often used. They allow longer holding pressure periods which help to control the pressure within this mold at a more constant level while it cools and contracts and thereby prevent voids and sinking. More positive and better ways of controlling these problems are through the use of nozzle or gate valves and mold pressure control. Mold temperatures must also be closely controlled since fast cooling results in bubbles, while slow cooling may produce sinks.

INJECTION MOLDING: TFCE resins

By J. A. Jupa*

Most of the molded applications of trifluorochloroethylene resins have been produced by injection molding but the material can also be compression molded if desired.

A major factor governing the molding, heat-treating techniques, and end uses of TFCE is its molecular weight. High molecular weight must be maintained to insure high tensile strength, elongation, toughness, and resistance to embrittlement in the finished parts.

ZST test

A fast and accurate check of the molecular weight of TFCE compounds can be obtained during fabrication, within a few minutes after a part has been produced, by means of the ZST (Zero Strength Time) test. This test measures the time (in sec.) required to break a standard notched strip which is weighted with a 7½-g. load at 250° C.; the result can be converted to the old NST system or directly to the value in centistokes as obtained by the solution-viscosity method. A specially designed ZST apparatus has been devised which is semi-automatic in operation and can easily be operated by nontechnical personnel.

Mold design

Molds for TFCE may be constructed from regular die steels, if subsequently chromium-plated, but it is safe to run sample shots before chrome-plating. High-grade chromium steels or Duranickel are also recommended for mold cavities. The use of short sprues, full-round runners, and round gates is suggested because TFCE has a high melt viscosity and sets up rapidly, even at elevated temperatures.

Mold shrinkage: Mold shrinkage on unplasticized and plasticized TFCE is to a great extent dependent upon the general size, weight, and geometric design of the piece, cylinder temperatures, and the effective pressure which is being applied under those temperatures.

Generally, the higher the cylinder temperature and the greater the weight of the piece, the greater the expected mold shrinkage. For unplasticized pieces having wall thickness from 0.025 to 0.125 in., mold shrinkage is between 0.005 and 10 mils per linear inch. As the thickness of the unplasticized piece increases, mold-shrinkage values will increase to 10 to 20 mils/inch.

Mold temperatures: High mold temperatures in the neighborhood of 290 to 310° F. are required for TFCE. These temperatures may be obtained by electrical heat, steam, or hot oil.

In many cases, it is difficult to reach the required mold temperatures unless special provisions are made to insulate the die from the heavy metal platens of the press. Satisfactory insulation can be achieved by using a Transite board approximately ⅛- to ¼-in. thick between the press platen and die. Also, the passage of hot oil or steam through one half of the die and then through the other half may result in a considerable differential in temperature; therefore, direct heating and control of each half of the die is suggested.

Uniform heating of the cavity areas must be seriously considered. Numerous molding difficulties have been traced to wide temperature variations between cavities. In order to check such variations, the strategic location of thermocouples in critical sections of the die may be indicated.

Molding characteristics

See Table, p. 625.

Cylinder temperature: Cylinder temperatures between 500 and 580° F. are usually found necessary for molding TFCE, but it is most important to keep the cylinder temperature at as low a point as possible to prevent thermal degradation. The temperature of the nozzle may be higher than the front and rear heaters.

If the machine must be stopped

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* Industrial Plastics and Equipment Co., Elizabeth, N. J.
References were prepared by the editors.

for a long period of time, the cylinder heat should immediately be lowered to a temperature of no more than 400° F.

If the melt in the cylinder is kept hot too long, it degrades and the molded pieces suffer from discoloration, brittleness, etc. Top safe temperature recommended for an exposure of 20 minutes is 550° F.

Molding pressures: It has been found necessary in many cases to use injection pressures of 30,000 p.s.i., and higher for molding TFCE. These pressures may be demanded by the character of the piece, general die design, and the effective pressure which the machine can supply at the nozzle. Because TFCE has a high melt viscosity, it is also necessary to displace the material quickly and to follow up with a consolidating pressure within the die before the material has an opportunity to "set up." Exerting higher molding pressures on the material also permits molding TFCE at somewhat lower temperatures.

In other cases, pressures below 30,000 p.s.i. have been satisfactory. Such factors as large gates or shooting the material directly into the die cavity have made the use of lower pressures possible. On occasion, wide variations in machine pressures of different machines have been found, even where the same die was used and the injection cylinder was held at approximately the same temperature.

Cold-runner molding

A good general rule for cold-runner molding is to use the lowest molding temperature possible within the range of 500 to 575° F. which will produce satisfactory molded pieces.

Using the lowest temperature —500° F. along the length of the cylinder—the molding operation may be started; if "short shots" are obtained, it is well to increase the cycle 100% or more. If "short shots" are still obtained, it will be desirable to raise the temperature approximately 20° F. and resume molding at the new level. If this condition does not produce satisfactory pieces, increase the length of the cycle again.

If the molder finds it necessary to go above the suggested temperatures, other changes must be made, such as an increase in pressure or opening up the sprues, runners, and gates, to obtain the necessary flow into the cavity of the die.

It is important to feed a quantity of material to the cylinder roughly equivalent to the weight of a "full shot." The feed setting should be so adjusted that the material cushion within the cylinder remains constant throughout the run. It is also desirable to keep the material cushion to a minimum in order to utilize the full effective pressure which the ram can supply.

TFCE plastic, in its molten state, has an extremely high viscosity and, consequently, its flow characteristics are generally inferior to those of other thermoplastics. Often, in order to fill cavities in the conventional two-plate die and cold-runner system, it has been necessary to overheat the material within the cylinder. This frequently results in material breakdown.

Hot-runner molding

The runners of a hot-runner mold system are designed to contain effectively the same weight of material as required in the molded pieces. This means that the injection cylinder acts as a preconditioner to bring the material gradually up to a temperature which will render the material flowable without excessive degradation. The final rendering of flowability is then done in a hot-runner system just prior to injection into the cavities. Since the material is in the hot-runner system for a relatively short time, a slightly higher final conditioning temperature is generally used by the molder.

With the hot-runner system, the scrap resulting from sprues, runners, and gates is reduced to a minimum. The sprues and runners are not removed from the mold after each shot; only the molded parts, with very small gates attached, are removed. This means that many small parts can be injection molded quite economically.

In hot-runner molding, only 100% virgin material is used. Since there are no sprues and runners to remove, the molder has no problem of providing storage space for scrap, or of contamination by re-using the material.

Higher quality, less orientation, and parts with higher molecular weight and optimum physical properties are also produced by the employment of a hot-runner mold.

The hot-runner system consists of an extension of the three-plate mold system. The third plate, which normally contains a sprue and runners which must be removed after each shot, is backed with a plate which is a mirror image of the third plate. The runner system thus enclosed is heated separately to temperatures well above the softening point of the polytrifluorochloroethylene plastic.

The third plate serves as a reservoir which can condition a quantity of material equivalent to that required for one shot. It is thus possible, by the aid of cavity feed bushings directly connected to this reservoir, to inject TFCE at essentially cylinder temperature directly into the cavity. The hot-runner section or reservoir is maintained at about 525° F.

Purging routine

Normally, if at all possible, it is recommended that the cylinder be dismantled and cleaned of other thermoplastic materials prior to running TFCE; however, if dismantling is not possible or practical, it may be desirable to use scrap TFCE for the purging operation.

References

For further information on fluorocarbon materials, see p. 103. For data on extrusion of TFCE, see p. 656. Also consult the Subject Index and the Directory Index.

"Upgrading fluorocarbon moldings," by Carmen R. Gianotta, MODERN PLASTICS *32*, 125 (Oct. 1954).

"Halofluorocarbon plastics," by Richard A. Smith, Julian H. Kushnick, and Herman S. Kaufman, Modern Packaging *31*, 131 (June 1958).

INJECTION MOLDING: FEP resins

By N. W. Todd*

An FEP (fluorinated ethylene propylene) resin (e.g., Teflon[1] 100) can be melt processed in conventional molding equipment[2]. It is suitable for continuous exposure at temperatures up to 400°F. The basic requirements for molding this resin include: 1) availability of sufficient heat within the cylinder and mold; 2) control of rate of injection; and 3) corrosion-resistant materials of construction.

Molding equipment

Any standard design injection cylinder properly sized for the intended job, can be used for molding FEP resin. It should be free of any restrictions which might cause hold-up of resin. The cylinder should be capable of being heated to 750° F. It is desirable to use independently controlled, zone-type heaters, and to provide three heating zones on the cylinder. Either a conventional or reverse taper nozzle may be used for molding FEP resin. The bore should be as large as possible, and designed to produce a streamlined flow of molten resin. The orifice diameter should also be as large as possible. Like the cylinder, the nozzle should be capable of being heated as high as 750° F.

Molds should be capable of being heated to 450°F. This can be done by using electric cartridge heaters. To reduce heat losses, the mold should be insulated from the platens.

For prolonged operations, as on a production basis, it is recommended that corrosion resistant materials be used wherever there is contact with molten resin. For short runs, such as tests or evaluations, no special materials are required. Materials particularly resistant to attack by fluorocarbon resins are high nickel alloys, such as "Duranickel" (International Nickel Co.) and "Hastelloy" C (Haynes-Stellite Co.). Chromium or nickel plating may be satisfactory for mold surfaces.

Molding conditions

The melt viscosity characteristics of Teflon 100 FEP-fluorocarbon resin are such that when the resin shear rate during flow exceeds a critical value, a condition of unstable flow results, known as melt fracture[3]. With proper control of processing conditions, melt fracture is not a problem. For a given size of orifice or channel through which the resin is flowing, shear rate is directly proportional to resin velocity. Thus, melt fracture is dependent on ram speed.

There are two general methods of preventing melt fracture: 1) reduce resin velocity, and 2) increase critical velocity. The first method can be accomplished by using large diameter runners and gates, and a slow ram speed. The second method is achieved by using a high stock temperature, since the critical velocity increases as stock temperature increases.

Stock temperature: Stock temperature should not exceed 750° F., since resin degradation is significant above this temperature. As hold-up time in the cylinder increases, stock temperature should be decreased. Stock temperatures in the range 700 to 750° F. are usually recommended, but in the molding of thick sections, and where a long hold-up time is encountered, lower temperatures must be used. Thick sections with large gates have been successfully molded using stock temperatures as low as 625°F.

Cylinder temperature: Cylinder and nozzle temperatures are adjusted to give the desired stock temperature. The settings used will depend on resin hold-up time, and location of the controlling thermocouples. In order to prevent resin degradation in case of a long hold-up time, the rear of the cylinder should be kept at a lower temperature than the front.

Pressure: In most cases, ram pressures between 5,000 and 20,000 p.s.i. will be satisfactory.

Mold temperature: High mold temperatures (400 to 450°F.) are essential in order to obtain molded parts having a good surface, and which do not delaminate upon being flexed. Care must be taken in cooling parts after ejection to minimize warping.

Ram speed: Control of ram speed during molding may be required in order to avoid melt fracture of the resin. This can easily be done by means of a flow control valve in the hydraulic system of the ram. The exact ram speed to use depends on the machine, shot size, stock temperature, and mold design. Generally, a slow speed is used except with very thin sections, where a fast ram may be required to prevent freeze-off before the cavity is filled.

Cycle: The length of the cycle required depends on the thickness of the part being molded, as shown in table of injection molding characteristics, p. 623. The greater portion of the cycle should be devoted to ram forward time, permitting the resin to solidify under pressure. For example, in a 1-min. cycle, the injection time might be 40 to 50 sec., and the cooling time 10 to 20 seconds.

Purging: It is good practice to have a separate cylinder for use only with FEP resin. If this cannot be done, it is helpful to purge the cylinder prior to using a lower melting resin. Reground cast acrylic sheeting is a suitable purge composition. When purging, cylinder temperatures should be reduced to 600°F., and adequate ventilation provided. Also, the front of the machine should be shielded in case of blow-out.

Mold design

Gates: Gates should be kept large and blended smoothly with cavities. Tab or fan type gates are often very effective. In some cases, gates may be located about ½ in. from the cavity, with an enlarged section between the gate and the cavity. Preferably, the enlarged section is at right angles to the runner. Properly designed, such a disposable tab or fan section prevents jetting, and restricts any surface defects to the disposable section.

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*Polychemicals Dept., E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.

[1] Trademark of E. I. du Pont de Nemours & Co., (Inc.)

[2] "Perfluorocarbon resin," SPE J. (Oct. 1958).

[3] "Melt fracture," SPE J., *12*, No. 2, 36 (1956).

Runners: Large diameter, full-round runners of the shortest possible length should be used. Runner walls should be smooth, and free of any restrictions or sharp corners. Runners should always blend in smoothly with gates. For parts up to about ½ in. in thickness, a ¼ in. diameter runner should be used. For thicker parts, the runner diameter should be between one-half to full thickness of the part.

Dimensional control

Molds for parts not requiring accurate dimensions can be constructed by allowing for a shrinkage of 30 to 60 mils/in. depending on the thickness of the part, as shown in the table on p. 623. Where accurate dimensions are required, a test cavity should be used to determine exact shrinkage allowances.

Since the usual service temperature for FEP resin will be equal to or lower than the mold temperatures used during molding, few dimensional changes due to stress relieving will be encountered. Molded parts have shown very little change in dimensions (measured at room temperature) after prolonged exposure in air at 450°F.

Handling of molding powder

Drying: Since FEP resin does not absorb moisture, drying of the resin before molding is not normally required.

Reworked material: Reground sprues, runners, and trimmings from molded FEP resin can be reused provided the material has not been degraded or contaminated. The same recommendations as for molding virgin material should be followed.

Safety precautions: When heated above 400°F. (204°C.), small quantities of gaseous decomposition products are evolved from fluorocarbon resins just as with other plastics. Some of these gases are unhealthy, and must be removed. A good exhaust should be provided at the point where the mold opens, near the nozzle, and over the cooling area.

FEP resin is believed to be just as harmless in contact with skin and if taken internally as the TFE resins.

INJECTION MOLDING: Vinyls

By Charles C. Swearingen*

The substantial increase in the use of vinyls reflects the continued improvements being made in materials, equipment, and techniques necessary for the successful molding of these versatile materials. Today's molders can take full advantage of the many unique properties of vinyls, with little danger of encountering the thermal instability difficulties of past years, providing, of course, that a reasonable amount of care is exercised. Because vinyls can be compounded or modified to give a very wide variety of physical and chemical characteristics, the comments which follow must necessarily be very general in nature.

It is, of course, very important that a molder using vinyls contact the supplier for specific information.

There are three basic classes of vinyls: 1) elastomeric (or flexible) vinyls; 2) rigid compositions based on copolymer resins; and 3) rigid compositions based on straight polyvinyl chloride resins. All of these materials are usually supplied in the form of granules or cubes, although some are occasionally available in powder form. The *elastomeric vinyls,* containing plasticizers, fillers, colors, lubricants, heat and light stabilizers, etc., can be handled quite readily in molding machines of conventional design. The *rigid copolymers,* containing stabilizers, lubricants, and colors, but no plasticizers or modifiers, are somewhat more difficult to mold by conventional methods. The *straight PVC rigids* are also compounded with the usual stabilizers, lubricants, and colors but are further classified into two types: Type I materials possess high heat-distortion points and outstanding chemical resistance; Type II formulations have exceptional impact resistance, but at a slight sacrifice in heat-distortion temperature and chemical resistance. Both Type I and Type II rigid PVCs are very difficult, if not impossible, to mold in conventional machines. Heat alone (below the thermal decomposition point) does not reduce the viscosity sufficiently for satisfactory molding. The flow curves of these materials indicate that they are somewhat thixotropic in nature and the employment of shear and agitation immediately prior to injection molding aids considerably in reducing the viscosity, thus producing a more strain-free, homogeneous molded part. A screw-preplasticating type of machine, therefore, is recommended for these materials.

Handling procedures

Predrying: Because of the extremely low moisture absorption of vinyls, predrying is not necessary. Preheating of the material is occasionally used to help shorten cycle times, this practice being applied primarily with molding compounds in the powder form rather than from cubes.

Handling: Normally, no difficulties are encountered in molding vinyl as long as time and temperature recommendations are followed. However, a considerable amount of HCl gas can be evolved if the compound decomposes due to exposure to excessive temperatures over a period of time.

Mold design

In general, the conventional mold design practices used with other molding materials should also be applied to vinyls. Adjacent thick and thin sections are to be avoided in the design of the piece, if possible, since this will lead to uneven cooling and shrinkage with resultant tendencies towards warpage and/or sink marks. Fillets should be used in corners, wherever possible, to minimize the possibility of flow lines and areas where high stress concentrations may occur.

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* Development Engineer, B. F. Goodrich Chemical Co., Avon Lake, Ohio.
References were prepared by the editors.

Since vinyls set up comparatively slowly in the mold, they have a tendency to flash at the pressures required to give full shots. High clamping pressures and plane mold faces eliminate this problem but at the same time make it necessary to pay particular attention to venting in order to avoid the formation of air pockets or blisters.

Vinyls reproduce mold surfaces with very great fidelity, so special care must be used in the finishing, handling, and maintenance of the molds. If a high gloss is desired on the finished piece, the cavities must be polished to mirror-brightness. Avoid rounding the edges of the cavities at the parting line as this will usually cause feather-edge flashing which is unsightly and difficult to trim.

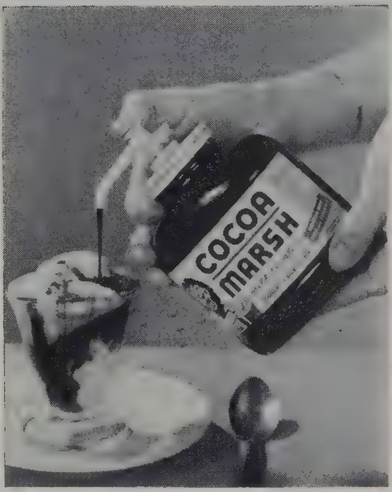
Removal of the finished pieces from the mold does not normally present any problems, even in cases where fairly deep undercuts are involved. With the harder compounds, properly placed knock-out pins are adequate; with the softer materials, an air blast is often used to eject the parts, or they may be stripped out by hand quite readily.

Runners: In designing the mold, account should be taken of the fact that vinyls form a rather viscous melt. With undersized runners, it may be very difficult, if not impossible, to fill the mold cavities completely. In practice, it has been found that full round runners from 3/16 to 3/8 in. in diameter are most satisfactory. The sprue bushing itself may taper to 3/8 or 1/2 in. in diameter.

Runners in a multicavity mold should be laid out so that the material flows the same distance to each cavity. Gates should be adjusted to give uniform filling times.

An important feature in runner design is the liberal use of cold-slugs or cold-wells to trap out the leading edge of chilled material flowing through the runners. If this material enters the mold cavity, it can cause many appearance defects, such as flow lines, weld lines, orange peel, etc. These cold-wells should not only be placed at the end of the main runner, they should also be placed in the secondary runners just before the gates.

Gating: The subject of gating is still a controversial one. Advantages and disadvantages can be found for all of the types which have been used. However, a small gate in the neighborhood of 30 mils in diameter has proven satisfactory in most cases (see table, p. 624). Its use generally promotes a better surface gloss on the molded articles because of frictional heat build-up as the material enters the cavity. There is no degating problems, and there is less tendency for shrinkage of the molded piece at the gate section.



INJECTION MOLDED of vinyl, syrup-dispensing pump eliminates dripping, will not clog

In most cases, gates should be full round and as small in diameter as possible without creating the need for excessive molding pressures. For a large molded piece, an undersize gate results in excessive mold filling time with a resultant inferior molding (dull streaks, poor welds, etc.).

Materials of construction: Tool steel is generally used in the construction of molds for vinyl, although beryllium copper is occasionally used. The pores of an unplated steel mold tend to absorb HCl during use. This sensitizes the metal to corrosion and it will rust readily, destroying the surface finish. For this reason, hard-chrome-plating over a copper and nickel underplating is strongly recommended. Flash-chroming is to be avoided, since it tends to be quite porous. HCl will penetrate these pores, corrode the surface of the steel underneath, and cause the plating to flake off. It is good practice with plated molds, and essential with unplated molds, to wipe on a generous coating of light oil any time the mold is not in use, even if only for a few hours.

Molding equipment

Cylinders: It is desirable to operate injection molding machines at less than rated capacity when running vinyls, because of their relatively low heat conductivity. A figure often used is 75% of rated capacity, which includes sprue, runners, and cavities. Some molders have overcome this necessarily lowered capacity by replacing the standard cylinder with an extra-capacity cylinder. This method permits a larger shot size and if properly used can actually result in better moldings. The temperatures used with an extra-capacity cylinder are generally lower than those required with a standard cylinder since the stock travels through more slowly and has more time to become plasticated. These lower temperatures minimize the chance of decomposition due to localized overheating.

Cylinders and spreaders used for vinyls must be designed to give good streamlined flow, as any material trapped in dead areas will soon decompose. A highly desirable design feature is a spreader which can be rather easily removed for periodic cleaning and inspection of the cylinder.

Recommended materials of construction for cylinders and spreaders are chrome-plated steel and Hastelloy C. Beryllium copper may also be used for spreaders. Hastelloy C is used as a liner and offers very good protection. It is somewhat expensive but for a machine being used constantly on vinyls, it may prove to be a worthwhile investment due to lower maintenance costs. It is possible to use plain carbon steel if very tight temperature control can be guaranteed. However, since iron tends to accelerate the decomposition of vinyls, accidental overheating could result in extreme pitting, essentially de-

VINYL SHOE BASE—heel, sole, and side vamps—is injection molded in single cavity mold. Uppers, die-cut from vinyl sheet, are attached by heat sealing or stitching. (Southern Plastics Engineering Corp.)

stroying the usefulness of the cylinder. A chrome-plated, carbon-steel cylinder is probably the most practical choice, considering both cost and serviceability. Again, as in the case of molds, it should be noted that chrome plating can be quite porous if not carefully done and if such porosity exists, the base metal can corrode and cause the chrome to flake off.

Nozzles: Special nozzles are not usually required with vinyls, although there are a few places where they may prove helpful. For example, when sprue-gating or center-gating precludes the use of cold-wells, a reverse taper nozzle will generally assist in the elimination of wavy or dull areas around the gate. Improved gloss and surface finish may sometimes be obtained by using a small nozzle opening for extra frictional heat build-up, providing, of course, that its use does not necessitate an excessive increase in pressure requirements or mold fill time. Dispersion nozzles can be used to promote color development and uniformity in cases where color pigments have been added by tumble mixing.

The nozzle should be equipped with heater bands powered through a variable transformer or other suitable means of adjusting temperature. Heat carried forward from the cylinder, if relied upon alone, does not permit sufficient control. Supplemental heaters of 100 to 200 watts capacity should be adequate in most cases.

Molding conditions

See Table, p. 624. As mentioned previously, there is such a wide variety of vinyl compounds available that the material supplier should always be consulted for complete information concerning each specific compound to be run.

In setting up a machine on vinyls, the start-up procedure described under "Purging" should be followed. Start out with a relatively long cycle and low temperatures, then slowly increase temperatures until full shots are obtained. Take care to prevent temperatures from overshooting the set values. Always allow ample time after each adjustment for conditions to stabilize before making further adjustments. Once the cycle has been established, it should be maintained with as little variation as possible.

Purging

It is of prime importance to keep the stock moving through the cylinder once temperatures of 250° F. or above have been attained. During start-up, occasional purge shots should be taken, increasing the frequency as the machine approaches molding temperature. Once in operation, the machine should never be allowed to stand idle, even for a few moments, or degradation and scorching will occur. For emergency maintenance or other temporary delays, shots should be purged through at a rate approximating that of the normal cycle time being used. In shutting down, the reverse of the heat-up procedure is followed, the heaters being turned off and the machine run or "flush cooled" to below 250° F.

If any discoloration is noted during regular operation, the temperatures should be lowered immediately and purge shots made until unfluxed material starts coming from the nozzle. Operation should then be resumed at lower temperatures.

Cleaning of the cylinder at regular intervals is good practice. This may be accomplished by thoroughly purging with a hard vinyl compound or one of the commercial purging compounds made especially for this purpose. Some have found that reground styrene saturated with a liberal quantity of mineral oil works well when allowed to sit in the cylinder for a few minutes. The mineral oil loosens any deposits and allows the hard styrene to scrape the walls clean. Temperatures should not exceed 300° F.

In the event of serious decomposition, it may be necessary to disassemble the cylinder and spreader for thorough cleaning.

Since it is difficult to flush out other molding materials with the softer vinyls, it often pays to have an extra cylinder for vinyls only.

References

For further information on elastomeric vinyls, see p. 171; on rigid vinyls, p. 178.

Also consult the Subject Index and the Directory Index.

"Effect of small quantities of plasticizers in PVC compounds," by P. Ghersa, Modern Plastics *36*, 135 (Oct. 1958).

"Injection molding rigid vinyl," Modern Plastics *31*, 113 (Dec. 1953).

"Restricted gating," by R. Bostwick and C. A. Joslin, Modern Plastics *31*, 125 (Oct. 1953).

"Plastics for chemical engineering construction—unplasticized polyvinyl chloride," by G. S. Laaff, Chem. Eng. Progress *50*, 275 (June 1954).

INJECTION MOLDING CHARACTERISTICS

Acrylic[1] (See p. 597)

Thickness of section:	*less than ⅛ in.*	*⅛ to ¼ in.*	*over ¼ in.*
A. *Temperatures, °F.*			
1) rear cylinder	480-500	480-500	480-500
2) mid cylinder	440-450	440-450	440-450
3) forward cylinder	440-450	440-450	440-450
4) nozzle	375-390	375-390	375-390
5) mold face	175-190	175-190	175-190
6) melt leaving nozzle	400-420	400-420	400-420
B. *Pressure exerted by ram, p.s.i.*			
1) in standard cylinder	15,000	20,000	20,000
2) in injection cylinder of preplasticating machine	3-5000	3-5000	3-5000
C. *Timing*			
1) total cycle (including mold-open time), sec.	35-40	40-60	60 per ¼ in.
2) ram forward time, sec.	10-15	15-25	30 and up
D. *Recommended gate dimensions*[2]			
1) If round, diameter, mils	75	120	187
land length, mils	70	70	70
2) If rectangular, depth, mils	75-90% of wall	75-90% of wall	75-90% of wall
width, mils	1½-2 × depth	1½-2 × depth	1½-2 × depth
land length, mils	70-80	70-80	70-80
E. *Annealing*			
1) medium	Hot-air circulated oven		
2) temperature, °F.	170	180	190
3) time, min.	120	120	120-240
F. *Shrinkage allowance, mils/in.*	Without annealing	Without annealing	Without annealing
1) in direction of flow	4	4	5
2) perpendicular to flow	3	3	4

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[1] Based on Grade 8 acrylic molding power. Temperatures under A should be lowered 30 to 50°F. for Grade 5. Table prepared by Rohm and Haas Co. [2] Assuming cavity volumes of 1, 4, and 16 cu. in. for the three section-thickness classes.

Cellulosics (See p. 600)

Thickness of section:	*less than ⅛ in.*	*⅛ to ¼ in.*	*over ¼ in.*
A. *Temperatures, °F.*			
1) rear cylinder	340-510	340-490	340-480
2) mid cylinder	340-510	340-510	340-510
3) forward cylinder	340-510	340-510	340-510
4) nozzle	300-460	300-460	300-460
5) mold face or mold coolant	70-180	70-180	70-160
6) melt leaving nozzle	330-450	330-430	330-430
B. *Pressure exerted by ram, p.s.i.*			
1) in standard cylinder	10,000-20,000	10,000-20,000	10,000-20,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	10-60	20-90	40-150
2) ram forward time, sec.	5-30	10-40	20-60
D. *Recommended gate dimensions*[1]			
1) If round, diameter, mils	25-50	25-50 and up	25-50
land length, mils	40	40	40
2) If rectangular, depth, mils	25-50	25-50 and up	25-50
width, mils	50-100	50-100	50-100
land length, mils	30-40	30-40	30-40
E. *Shrinkage allowance, mils/in.*	Without annealing	Without annealing	Without annealing
1) in direction of flow	2-7	2-15	4-25
2) perpendicular to flow	2-7	2-15	4-25

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[1] (Assuming cavity volumes of 1, 4, and 16 cu. in. for the three section-thickness classes.) Gating dimensions listed are based on the restricted type of gate and are applicable as starting recommendations for all cavity sizes within the given limitations. Gates may be enlarged, particularly in the large-size, heavier-thickness cavities, if necessary.

Nylon 6/6[1] (See p. 602)

Thickness of section:	*less than ⅛ in.*	*⅛ to ¼ in.*	*over ¼ in.*
A. *Temperatures, °F.*			
1) rear cylinder	600-700	600-650	600-625
2) mid cylinder	550-650	525-600	525-550
3) forward cylinder	525-600	510-525	500-510
4) nozzle	To suit	To suit	To suit
5) mold face or mold coolant	70-200	140-200	180-200
6) melt leaving nozzle	525-575	510-520	500-510
B. *Pressure exerted by ram, p.s.i.*			
1) in standard cylinder	15,000-30,000	15,000-30,000	15,000-30,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	30	30-60	60 sec./¼ in. section
2) ram forward time, sec.	20	20-40	40 sec./¼ in. section
D. *Recommended gate dimensions*[2]			
1) If round, diameter, mils	30 to ½ thickness of part	30 to 120	120 to 180
land length, mils	Same as above		
2) If rectangular, depth, mils	Equal to ½ dia. of gate		
width, mils	Area equal to round dimensions		
land length, mils	Same as above		
E. *Annealing*			
1) medium	Glyco wax S932 or Teresso 140 oil		
2) temperature, °F.	300	300	300
3) time, min.	10-15	15-30	30
F. *Shrinkage allowance, mils/in.*	With annealing		
1) in direction of flow	15-20	20-30	30-40
2) perpendicular to flow	Same as above or use test cavity		

[1] Prepared by Du Pont. [2] Assuming cavity volumes of 1, 4, and 16 cu. in. for the three section-thickness classes.

Vinyl[1] (See p. 620)

Thickness of section:	*(Flexible) less than ⅛ in.*	*(Flexible) ⅛ to ¼ in.*	*(Rigid) over ¼ in.*
A. *Temperatures, °F.*			
1) rear cylinder	290-330	290-330	310-330
2) mid cylinder	300-340	300-340	320-340
3) forward cylinder	310-350	310-350	330-350
4) nozzle	320-360	320-360	340-360
5) mold face or mold coolant	110-140	110-140	140
6) melt leaving nozzle	320-360	320-360	350-370
B. *Ram pressure, p.s.i.*			
1) in standard cylinder	10,000-20,000	10,000-20,000	20,000-30,000
2) in injection cylinder of preplasticator	—	—	—
C. *Timing*			
1) total cycle (including mold-open time), sec.	30-60	30-120	60-240
2) ram forward time, sec.	3-10	4-20	30-60
D. *Recommended gate dimensions*[2]			
1) If round, diameter, mils	25-40	30-125	250-500
land length, mils	60	60-250	Small as possible
2) If rectangular, depth, mils	—	20	250
width, mils	—	60	500
land length, mils	—	60	Small as possible
E. *Shrinkage allowance, mils/in.*	Without annealing		
1) In direction of flow	10-30	10-30	4-6
2) Perpendicular to flow	10-30	10-30	4-6

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[1] Prepared by Goodrich

[2] Assuming cavity volumes of 1, 4, and 16 for the three section thicknesses

Polypropylene[1] (See p. 613)

Thickness of section:	*less than ⅛ in.*	*⅛ to ¼ in.*	*over ¼ in.*
A. *Temperatures, °F.*			
1) rear cylinder	475-600	450-525	450-525
2) mid cylinder	475-600	450-525	450-525
3) forward cylinder	425-550	400-475	400-475
4) nozzle	400-500	400-500	400-500
5) mold face or mold coolant	60-180	60-220	100-220
6) melt leaving nozzle	450-525	450-525	450-525
B. *Ram pressure, p.s.i.*			
1) in standard cylinder	10,000-30,000	8,000-30,000	8,000-30,000
2) in injection cylinder of preplasticator	8,000-30,000	6,000-30,000	6,000-30,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	6-45	30-90	60-120
2) ram forward time, sec.	1-15	5-30	10-40
D. *Recommended gate dimensions*[2]			Max. limited by runner size
1) If round, diameter, mils	20-250	40-375	
land length, mils	40 max.	40 max.	— —
2) If rectangular, depth, mils	10 min.	30 min.	—
width, mils	—	—	—
land length, mils	40 max.	40 max.	60 max.
E. *Shrinkage allowance, mils/in.*	Without annealing		
1) In direction of flow	10-25	10-25	12-30
2) Perpendicular to flow	10-20	10-20	12-25

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[1] Prepared by Hercules. Maximum gate dimensions limited by part dimensions and sprue and runner capacity.

Nylon 6[1] (See p. 605)

Thickness of section:	*less than ⅛ in.*	*⅛ to ¼ in.*	*over ¼ in.*
A. *Temperatures, °F.*[2]			
1) rear cylinder	470-580	460-580	460-580
2) mid cylinder	450-560	440-560	440-560
3) forward cylinder	450-560	440-560	440-560
4) nozzle	430-500	430-500	430-500
5) mold face or mold coolant	70-200	70-200	70-200
6) melt leaving nozzle	460-530	450-520	440-510
B. *Pressure exerted by ram, p.s.i.*			
1) in standard cylinder	12,000-27,000	12,000-27,000	12,000-27,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	15-30	25-60	40-120
2) ram forward time, sec.	5-20	10-40	20-60
D. *Recommended gate dimensions*[3]			
1) If round, diameter, mils	40 to ½ thickness of part	40 to 120	120 to 180
land length, mils	Maximum 40	Maximum 60	Max. ½ dia. of gate
2) If rectangular, depth, mils	½ to full thickness of part	½ thickness of part	120-180
width, mils	Full thickness of part (min. 60)	½ to ¾ thickness of part	180
land length, mils	Maximum 40	Maximum 60	Maximum 125
E. *Annealing*			
1) medium	Glyco wax S932 or Teresso 140 oil.		
2) temperature, °F.	275	275	275
3) time, min.	10	20	30
F. *Shrinkage allowance, mils/in.*	With annealing	With annealing	With annealing
1) in direction of flow	8-15	15-17	17-22
2) perpendicular to flow	Same as above	Same as above	Same as above

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[1] Prepared by Spencer Chemical Co.

[2] Cylinder temperature settings should be adjusted according to the rate at which the material must be plasticized.

[3] Assuming cavity volumes of 1, 4, and 16 cu. in. for the three section-thickness classes.

Unplasticized Polytrifluorochloroethylene[1] (See p. 617)

Thickness of section:	*less than ⅛ in.*	*⅛ to ¼ in.*	*over ¼ in.*
A. *Temperatures, °F.*			
1) rear cylinder	500-540	500-540	——
2) mid cylinder	520-560	520-560	——
3) forward cylinder	540-580	540-580	——
4) nozzle	540-580	540-580	——
5) mold face or mold coolant	200-320	200-320	——
6) melt leaving nozzle	540-580	540-580	——
B. *Ram pressure, p.s.i.*			
1) in standard cylinder	30,000-40,000	24,000-30,000	20,000-25,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	40	60-90	70-120
2) ram forward time, sec.	10	15	25
D. *Recommended gate dimensions*			
1) If round, diameter, mils	62	62-125	125-250
land length, mils	62	62-187	125-187
E. *Annealing*			
1) medium	air	air	air
2) temperature, °F.	250	250	250
3) time, hr.	8	8	8
F. *Shrinkage allowance, mils/in.*	5-25	5-25	5-25

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[1] Prepared by J. A. Jupa, Industrial Plastics and Equipment Co., Elizabeth, N. J.

[2] Assuming cavity volumes of 1, 4, and 16 cu. in. for the three section-thickness classes.

FEP-Fluorocarbon Resin[1] (See p. 619)

Thickness of section:	*less than ⅛ in.*	*⅛ to ¼ in.*	*over ¼ in.*
A. *Temperatures, °F.*			
1) rear cylinder	650-700	650-700	650-700
2) mid cylinder	700-725	700-725	675-725
3) forward cylinder	700-750	700-750	675-750
4) nozzle	700-750	700-750	675-750
5) mold face or mold coolant	400-450	400-450	400-450
6) melt leaving nozzle	700-750	700-750	675-750
B. *Ram pressure, p.s.i.*			
1) in standard cylinder	5,000-20,000	5,000-20,000	5,000-20,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	30-50	50-90	60-120
2) ram forward time, sec.	20-40	40-60	50-90
D. *Recommended gate dimensions*			
1) If round, diameter, mils	62-125	125-187	187-250
land length, mils	30	30-60	30-60
E. *Annealing*			
1) medium	——	——	——
2) temperature, °F.	——	——	——
3) time, hr.	——	——	——
F. *Shrinkage allowance, mils/in.*	30-40	35-50	35-60

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[1] Based on Teflon 100, prepared by E. I. du Pont de Nemours & Co., (Inc.).

Acetal Resin[1] (See p. 594)

Thickness of section:	1/16 inch	1/8 inch	1/4 inch
A. *Temperatures, °F.*			
1) rear cylinder	420-440	cylinder temperature is dependent upon size of the machine, shot weight, cycle, gating, etc.	
2) mid cylinder	420-440		
3) forward cylinder	420-440		
4) nozzle	390		
5) mold face or mold coolant	150-250	150-200	150-200
6) melt leaving nozzle	420	400	390
B. *Pressure exerted by ram, p.s.i.*			
1) in standard cylinder	15,000-20,000	15,000-20,000	15,000-20,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	30	45	60
2) ram forward time, sec.	15	25	30
D. *Recommended gate dimensions*[2]			
1) If round, diameter, mils	35	60	100
land length, mils	40	40	40
2) If rectangular, depth, mils	32	51	90
width, mils	32	51	90
land length, mils	40	40	40
E. *Annealing*			
1) medium	"Primol" D[3]	"Nujol"[3]	"Uniflo"[3]
2) temperature, °F.	320 ± 3	320 ± 3	320 ± 3
3) time, min.	15	15	15
F. *Shrinkage allowance, mils/in.*[4]	Without annealing	Without annealing	Without annealing
1) in direction of flow	23	26	27
2) perpendicular to flow	23	26	27

[1] Based on "Delrin" acetal resin, E. I. du Pont de Nemours & Co., Inc. [2] Assuming cavity volumes of 1, 4, and 16 cu. in. for the three section-thickness classes. [3] "Primol" D registered trademark, Esso Standard Oil Co.; "Nujol," registered trademark, Plough, Inc.; "Uniflo," registered trademark, Standard Oil of New Jersey. [4] With typical gate size shown above.

Polystyrene[1] (See p. 615)

Thickness of section	to 1/8 in.	1/4 to 1/8 in.	over 1/4 in.
A. *Temperatures, °F.*			
1) rear cylinder	350-550	325-500	300-475
2) mid cylinder	375-575	350-525	325-500
3) forward cylinder	400-600	375-550	350-525
4) nozzle	375-575	350-525	325-500
5) mold face or mold coolant	90-150	90-150	90-150
6) melt leaving nozzle	350-500	325-450	300-415
B. *Ram pressure, p.s.i.*			
1) in standard cylinder	10,000-20,000	10,000-20,000	10,000-20,000
2) in injection cylinder of preplasticating machine	10,000-20,000	10,000-20,000	10,000-20,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	4-60	20-90	40-150
2) ram forward time, sec.	1-30	8-40	15-60
D. *Recommended gate dimensions*[2]			
1) If round, diameter, mils	30-250	30-250	30-250
land length, mils	30 min.	30 min.	30 min.
2) If rectangular, depth mils	25-50	25-100	25-150
width, mils	Dia. of runner less 1/16 in.	Dia. of runner less 1/16 in.	Dia. of runner less 1/16 in.
land length, mils	30 min.	30 min.	30 min.
E. *Annealing*			
1) medium	air or water	air or water	air or water
2) temperature, °F.	160-170	160-170	160-170
3) time, min.	10-50	50-120	120 and up
F. *Shrinkage allowance, mils/in.*	Without annealing		
1) in direction of flow	2-8	2-15	4-25
2) perpendicular to flow	2-8	2-15	4-25

[1] Based on general-purpose Styron 666, Dow Chemical Co. [2] Assuming cavity volumes of 1, 4, and 16 cu. in. for the three section-thickness classes.

Med.-Density P/E[1] (See p. 609)

Thickness of section	to 1/8 in.	1/8 to 1/4 in.	over 1/4 in.
A. *Temperatures, °F.*			
1) rear cylinder	300-500	300-400	275-350
2) mid cylinder	475-650	400-500	300-400
3) forward cylinder	500-650	450-550	350-450
4) nozzle	400-550	350-500	350-450
5) mold face or mold coolant	40-200	60-200	100-200
6) melt leaving nozzle	450-600	400-500	300-450
B. *Ram pressure, p.s.i.*			
1) in standard cylinder	5,000-30,000	5,000-30,000	5,000-30,000
2) in injection cylinder of preplasticating machine	5,000-30,000	5,000-30,000	5,000-30,000
C. *Timing*			
1) total cycle (including mold-open time), sec.	10-60	25-75	40-120
2) ram forward time, sec.	5-25	10-30	15-40
D. *Recommended gate dimensions*			
1) If round, diameter, mils	25-250	40-250	100-250
land length, mils	25-75	25-75	50-100
2) If rectangular, depth mils	25-125	40-187	100-250
width, mils	25-125	40-187	100-250
land length, mils	25-75	25-75	50-100
E. *Annealing*			
1) medium	water	water	water
2) temperature, °F.	212	212	212
3) time, min.	15-30	15-30	15-30
F. *Shrinkage allowance, mils/in.*	Without annealing		
1) in direction of flow	18-40	18-50	18-60
2) perpendicular to flow	18-40	18-50	18-60

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[1] Prepared by Spencer Chemical Co.

Check list of defects and causes in

Injection molded plastics parts

CELLULOSICS

Defect: Incomplete or short shots

Possible causes

☐ Material temperature too low
☐ Injection pressure too low
☐ Insufficient feed
☐ Excessive feed build-up in cyl.
☐ Machine undersized for shot size
☐ Undersized nozzle orifice, runners, or gates
☐ Inadequate venting of cavities

Defect: Sink or shrink marks

Possible causes

☐ Insufficient pressure
☐ Ram forward time too short
☐ Insufficient feed
☐ Material too hot
☐ Improperly located gate (relocate large gate to heavy section of part; restricted gate to thin section)

Defect: Mica specks, bubbles, or surface blisters

Possible causes

☐ Material insufficiently dried
☐ Material too hot
☐ Contamination
☐ Insufficient pressure
☐ Excessive mold lubricant

Defect: Poor welds, flow marks

Possible causes

☐ Material too cold
☐ Inadequate pressure
☐ "Worming" or "jetting" caused by improper gate location or direction of entry into cavity.
☐ Mold too cold

Defect: Brittleness

Possible causes

☐ Molding temperature too low
☐ Material breakdown
☐ Improper material formulation
☐ Poor welds

Defect: Moist surface or cloudy appearance of moldings

Possible causes

☐ Insufficient mold venting
☐ Material or mold too cold
☐ Improper material formulation
☐ Material improperly dried
☐ Excessive mold lubricant

TFCE RESINS

Defect: Short shots

Possible causes

☐ Pressure too low
☐ Cycle too short
☐ Temperature too low

Defect: Bubbles, large (vacuum bubbles)

Possible causes

☐ Die temperatures too low
☐ Cylinder temperatures too high
☐ Length of dwell too short

Defect: Many fine bubbles (indicates excessive material breakdown)

Possible causes

☐ Cylinder temperatures too high
☐ Shorten cycle, if possible

Defect: Brittleness

Possible causes

☐ Cylinder temperatures too high

Defect: Poor weld

Possible causes

☐ Die temperature too low (raise to a maximum of 320° F.)
☐ Pressure too low (open gates and runners to increase pressure)

Defect: Frosted appearance

Possible causes

☐ Material or die temp. too low

Defect: Discoloration

Possible causes

☐ Contamination

Defect: Variable fill

Possible causes

☐ Non-uniform feed

Defect: Flow marks

Possible causes

☐ Die temperature too low

NYLON 6/6

Defect: Blisters and splay marks

Possible causes

☐ Wet or overheated materials
☐ Slow filling of mold
☐ Front of cylinder too hot, rear too cold

Defect: Weld marks

Possible causes

☐ Material too cold
☐ Pressure too low
☐ Slow filling of mold
☐ Poor venting

Defect: Burn marks on surface

Possible causes

☐ Poor venting
☐ Filling too fast

Defect: Discoloration or brown streaks

Possible causes

☐ Rear heat of cylinder too high
☐ Too much wattage over section of cylinder where ram works
☐ Insufficient pad of material between ram and cylinder after shot is taken
☐ Ram out-time too long
☐ Long delays between cycles
☐ Machine operating a short time after start-up

Defect: Reduced toughness

Possible causes

☐ Wet or overheated material
☐ Mold too hot
☐ Non-uniform wall sections in part
☐ Sharp angles in flow within the cavity (where possible, use radius at meeting of any two sections)
☐ Wrong position of gate (do not locate gate at any point where flexing occurs)
☐ Gate too sharp at entry to cavity (blend with generous radius)
☐ Excessive dirt, fillers, or pigments used in material
☐ Gate too small

Defect: Inability to hold dimensional tolerances

Possible causes

☐ Erratic performance of hydraulic or electric systems of machine
☐ Non-uniform cycles
☐ Gates too small and/or too long
☐ Runner system too long or too complex
☐ Too many cavities
☐ Worn clamp platen bearings
☐ Mold leader pins binding
☐ Non-uniform feeding of material
☐ Material not uniformly dried
☐ Material not uniformly heated

Defect: Ejection difficulties

Possible causes

☐ Insufficient draft angle
☐ Cavity surfaces too smooth
☐ Cycle too short or too long
☐ Material injected too hot
☐ Wrong type of knock-out
☐ Insufficient venting
☐ Incorrect mold temp.
☐ Wall sections too thin
☐ Pressure too high or low

Defect: Internal voids and surface sinks

Possible causes

☐ Pressure too low
☐ Cycle too short

Check list for TFCE resins prepared by J. A. Jupa, Industrial Plastics and Equip. Co.; check list for nylon 6/6 prepared by Louis Paggi, E. I. du Pont de Nemours & Co., Inc.; check list for nylon 6 prepared by Robert F. Flaherty, Plastics and Coal Chemicals Div., Allied Chemical Corp.; check list for polyethylene prepared by K. A. Kaufmann and C. S. Imig, Spencer Chemical Co.; check list for styrene prepared by L. W. Meyer, The Dow Chemical Co.; check list for vinyls prepared by Charles C. Swearingen, B. F. Goodrich Chemical Co.; check list for acrylics prepared by Rohm & Haas Co.; check list for polypropylene prepared by Hercules Powder Co.; check list for acetal prepared by E. I. du Pont de Nemours & Co., Inc. Sections on polyethylene reviewed by U. S. I. Chemical Co. and Phillips Chemical Co.; sections on nylon 6 reviewed by Spencer Chemical Co.

- ☐ Filling rate too fast
- ☐ Material too hot
- ☐ Gates too long and/or too small
- ☐ Runners too small
- ☐ Lack of radii in flow stream

NYLON 6

Defect: Variations in dimensions

Possible causes

- ☐ Non-uniform feeding of material
- ☐ Large variations in cylinder temperatures
- ☐ Too many cavities necessitating complex runner system
- ☐ Non-uniform gates
- ☐ Reground material not uniformly mixed with virgin
- ☐ Material placed in the hopper at non-uniform temperature
- ☐ Non-uniform time cycles—operator varying mold-open time between shots
- ☐ Inconsistent mold clamping or injection pressure

Defect: Flashing

Possible causes

- ☐ Cavity plates dented or warped
- ☐ Mold clamping pressure not properly adjusted
- ☐ Material overheated
- ☐ Injection pressure too high
- ☐ Inadequate venting or vents blocked

Defect: Spray marks (silver streaks on the surface of the molding)

Possible causes

- ☐ Wet material
- ☐ Material overheated
- ☐ Low boiling wetting agent used for dry blending

Defect: Weld marks

Possible causes

- ☐ Inadequate or blocked vents
- ☐ Mold too cold
- ☐ Material too cold
- ☐ Pressure too low
- ☐ Injection rate too slow

Defect: Burn marks

Possible causes

- ☐ Material overheated
- ☐ Injection rate too fast
- ☐ Inadequate or blocked vents

Defect: Voids and sink marks

Possible causes

- ☐ Gates too long and/or too small
- ☐ Materials overheated
- ☐ Feed backed up causing high loss of injection pressure
- ☐ Injection pressure too low
- ☐ Sprue and/or runners too small
- ☐ Ram forward time too short
- ☐ Injection rate too fast

Defect: Discoloration

Possible causes

- ☐ Material overheated in injection cylinder
- ☐ Material oxidized by drying too long and/or at too high a temp.
- ☐ Discolored material not purged during start-up

Defect: Ejection difficulties

Possible causes

- ☐ Cycle too short
- ☐ Material too hot
- ☐ Poorly designed knockout system
- ☐ Injection pressure too high
- ☐ Inadequate draft angles

Defect: Lack of toughness (brittleness)

Possible causes

- ☐ Wet or overheated material
- ☐ Gate located improperly (do not locate the gate at a point of high stress)
- ☐ Sharp turns in flow in cavity
- ☐ Contamination or excessive amount of fillers or pigment

POLYETHYLENE

Defect: Incomplete or short shots

Possible causes

- ☐ Insufficient pressure
- ☐ Insufficient feed
- ☐ Stock temperature too low
- ☐ Mold temperature too low
- ☐ Insufficient injection time
- ☐ Foreign material clogging nozzle or gates

Defect: Sink or shrink marks

Possible causes

- ☐ Insufficient pressure
- ☐ Insufficient dwell time
- ☐ Gates, runners or sprue too small
- ☐ Stock temperature too high
- ☐ Mold temp. too high

Defect: Bubbles

Possible causes

- ☐ Stock temperature too high
- ☐ Insufficient pressure

Defect: Voids

Possible causes

- ☐ Stock temperature too low
- ☐ Mold temperature too low
- ☐ Insufficient dwell time
- ☐ Insufficient pressure
- ☐ Gates too small

Defect: Delamination

Possible causes

- ☐ Stock temperature too high
- ☐ Inj. time too long (if around gate)
- ☐ Inj. press. too low
- ☐ Mold temp. too low
- ☐ Contamination by incompatible resin

Defect: Poor welds

Possible causes

- ☐ Stock temperature too low
- ☐ Improper gate location or type
- ☐ Injection pressure too low
- ☐ Mold temp. too low
- ☐ Air entrapment due to improper venting

Defect: Flow marks

Possible causes

- ☐ Stock temperature too low
- ☐ Mold temp. too low
- ☐ Incorrect injection pressure
- ☐ Melt index too low

Defect: Brittleness

Possible causes

- ☐ Stock temperature too low
- ☐ Degraded material in cylinder
- ☐ Improper mold temp.
- ☐ Packing by excessive ram dwell and resin feed

Defect: Poor color dispersion

Possible causes

- ☐ Gates too large
- ☐ Inadequate dispersion nozzle
- ☐ Pigment agglomeration from adding too much coloring aid and improper tumbling
- ☐ Poor-quality pigments

STYRENE

Defect: Silver streaking

Possible causes

- ☐ Plastic temperature too high
- ☐ Mixture of coarse and fine granules (as with reground)
- ☐ Exceeding plasticizing capacity
- ☐ Air trapped between granules in cold end of machine
- ☐ Moisture on granules
- ☐ Intermittent flow in the cavity
- ☐ Injection speed too fast
- ☐ Mold temperature too low

Defect: Black streaks

Possible causes

- ☐ Frictional heat caused by movement of cold granules past one another and compression of air in feed end of cylinder
- ☐ Air trapping in mold
- ☐ Plunger off center, causing friction burning of material
- ☐ Plastic burning in nonstreamline areas or cracks in heating cylinder

Defect: Bubbles

Possible causes

- ☐ Not enough plastic in the mold to prevent excessive shrinkage due to: a) heavy sections, bosses, and ribs; b) injection pressure too low; c) plunger forward time too short; and d) insufficient feed
- ☐ Moisture on granules
- ☐ Non-uniform mold temperature
- ☐ Air trapping

Defect: Sink marks

Possible causes

- ☐ Not enough plastic in the mold to allow for shrinkage
- ☐ Plastic too hot
- ☐ No cushion in front of ram

Defect: Poor or obvious weld lines

Possible causes

- ☐ Plastic too cold
- ☐ Excess mold lubricant on mold
- ☐ Weld line too far from gate
- ☐ Air unable to escape from mold fast enough

- ☐ Section thickness variation within part
- ☐ Mold too cold
- ☐ Insufficient pressure
- ☐ Slow injection speed

Defect: Poor surface

Possible causes

- ☐ Mold too cold
- ☐ Injection pressure too low
- ☐ Water on mold face
- ☐ Excess mold lubricant on mold
- ☐ Not enough plastic into mold to contact mold metal at all points
- ☐ Slow ram speed
- ☐ Excessive lubricants

Defect: Warping

Possible causes

- ☐ Part ejected too hot
- ☐ Plastic too cold
- ☐ Variation of section thickness or contour of part
- ☐ Unbalanced gates
- ☐ Excessive material discharged from or packed into the area around the gate

Defect: Parts sticking in the mold

Possible causes

- ☐ Injection pressure or cylinder temperature too high
- ☐ Too much feed
- ☐ Plunger forward time too long
- ☐ Unbalanced gates
- ☐ Undercuts in mold
- ☐ Vacuum under deep draw part

Defect: Brittleness and crazing

Possible causes

- ☐ Packing excess plastic into mold
- ☐ Plastic too cold
- ☐ Oil and grease on knockout pins
- ☐ Mold temperature too low
- ☐ Molding general-purpose polystyrene around metal inserts

Defect: Short shots

Possible causes

- ☐ Cold material
- ☐ Cold mold
- ☐ Insufficient pressure
- ☐ Poor venting
- ☐ Insufficient plunger forward time
- ☐ Improper balance of plastic flow in multiple cavity molds
- ☐ Insufficient injection speed

Defect: Flash

Possible causes

- ☐ Material too hot
- ☐ Pressure too high
- ☐ Excessive feed
- ☐ Poor parting line or mating surfaces
- ☐ Insufficient clamp

Defect: Sprue sticking

Possible causes

- ☐ Excessive pressure
- ☐ Hot material
- ☐ Insufficient draft
- ☐ Improper fit between sprue bushing and nozzle
- ☐ Undercuts or rough surface
- ☐ Long plunger dwell

Defect: Erratic cycles

Possible causes

- ☐ Holding gates open varying lengths of time
- ☐ Erratic pressures
- ☐ Erratic feed

Defect: Long cycles

Possible causes

- ☐ High material temperatures
- ☐ Mold temperature excessive
- ☐ Insufficient heating capacity
- ☐ Excessive flash

Defect: Flow lines and folds

Possible causes

- ☐ Plastic cold
- ☐ Mold cold
- ☐ Gates too small
- ☐ Non-uniform section thickness

Defect: Dimensional variation

Possible causes

- ☐ Molding conditions erratic
- ☐ Variation in ambient air temp.

Defect: Low heat distortion temperature

Possible causes

- ☐ Excessive pressure
- ☐ Excessive plunger dwell
- ☐ Excessive mold temperature
- ☐ Gate slow freezing
- ☐ Variations in section thickness
- ☐ Too low mold temperature
- ☐ Incorrect cylinder temperature relative to mold temperature

VINYLS

Defect: Incomplete or short shot

Possible causes

- ☐ Insufficient feed
- ☐ Insufficient pressure
- ☐ Stock too cold (or too short a cycle)
- ☐ Too short ram forward time
- ☐ Cylinder packing, excessive feed
- ☐ Improper venting of the mold
- ☐ Gate too small for cavity size

Defect: Sink or shrinkage marks

Possible causes

- ☐ Insufficient feed
- ☐ Insufficient pressure
- ☐ Too short ram forward time
- ☐ Improper mold gating
- ☐ Improper mold design (adjacent thick and thin sections)

Defect: Smudges, orange peel (generally around the gate)

Possible causes

- ☐ Too long ram forward time
- ☐ Injection pressure too high
- ☐ Stock temperature too high

Defect: Dull streaks, flow lines

Possible causes

- ☐ Stock temperature too low
- ☐ Runners too small
- ☐ Improper gate size and/or location
- ☐ Stock too hot (if discolored)
- ☐ Inadequate cold-wells

Defect: Weld lines

Possible causes

- ☐ Stock temperature too low
- ☐ Runners too small
- ☐ Inadequate cold wells
- ☐ Improper gate size or location
- ☐ Improper mold design (very long thin sections)
- ☐ Mold too cold

Defect: Flashing

Possible causes

- ☐ Injection pressure too high
- ☐ Insufficient clamping pressure
- ☐ Stock temperature too high
- ☐ Mold faces not plane and parallel
- ☐ Improper venting (one cavity flashing while another fails to fill)

Defect: Blisters or bubbles

Possible causes

- ☐ Stock temperature too high (generally accompanied by decomposition)
- ☐ Trapped air due to improper venting (often in corners of raised letters or designs, etc.)

Defect: Burned spots

Possible causes

- ☐ Too high a ram speed
- ☐ Improper venting
- ☐ Stock temperature too high

Defect: Excessive shrinkage at gate

Possible causes

- ☐ Stock temperature too low or too high
- ☐ Insufficient ram forward time

Defect: Warping

Possible causes

- ☐ Excessive ram forward time
- ☐ Insufficient cooling in mold (too short a cycle)
- ☐ Improperly designed knockouts or ejectors

Defect: Stock discoloration or breakdown

Possible causes

- ☐ Stock temperature too high
- ☐ Cycle too long or erratic
- ☐ Gate too small (frictional heat breakdown)
- ☐ Machine not properly purged during start up or shut down

Defect: Black flecks but no discolored streaks

Possible causes

- ☐ Decomposed material from previous run flaking off cylinder walls

ACRYLICS

Defect: Short shot

Possible causes

- ☐ Insufficient feed
- ☐ Injection pressure too low
- ☐ Temperature of cylinder and/or mold too low
- ☐ Excessive feed
- ☐ Undersized gates, sprues, runners, or nozzle

Defect: Weld lines

Possible causes

☐ Low pressure
☐ Temperature of cylinder and/or mold too low
☐ Improper location or type of gate
☐ Varying section thickness

Defect: Tails (welds or tears beyond raised numerals, etc., in the mold)

Possible causes[1]

☐ Cylinder temperature too high
☐ Mold temperature too low
☐ Pressure too low
☐ Injection rate too fast
☐ Cylinder temperature too low
☐ Improper location or type of gate
☐ Improper mold design

Defect: Tear drops, mica surface, blisters, bubbles, splash, flow lines

Possible causes

☐ Insufficient predrying
☐ Injection pressure too low
☐ Cylinder temperature too high
☐ Mold temperature too low
☐ Undersized gates, sprue, or nozzle
☐ Injection speed too fast
☐ Air trapped at feed end of cyl.

Defect: Sink marks

Possible causes

☐ Injection pressure too low
☐ Ram forward time too short
☐ Cylinder temperature too high
☐ Mold temperature too low
☐ Undersized gates, sprue, runners, or nozzle

Defect: Smudge, orange peel, skids

Possible causes

☐ Ram forward time too long
☐ Injection pressure too high
☐ Temp. of cyl. or mold too high

Defect: Cold slug

Possible causes

☐ Nozzle temperature too low
☐ Absence of cold slug well opposite sprue design

Defect: Internal bubbles in thick molded pieces

Possible causes

☐ Ram forward time too short
☐ Ram pressure too low
☐ Cycle too short
☐ Ram speed too great
☐ Cylinder temperature too high
☐ Improper annealing after ejection (water too cold will cause vacuum bubbles; water too hot will tend to open up weld lines)
☐ Undersized gates, runners, sprue, or nozzle

Defect: Warping

Possible causes[2]

☐ Insufficient cooling in mold (too short a cycle)
☐ Temperature of cylinder and/or mold too high
☐ Improper piston forward time

POLYPROPYLENE

Defect: Incomplete or short shot

Possible causes

☐ Insufficient feed
☐ Insufficient pressure
☐ Stock temperature too low
☐ Mold temperature too low
☐ Insufficient injection time
☐ Foreign material clogging nozzle or gates
☐ Cylinder heating capacity undersized for shot size
☐ Restriction in flow due to undersized runners or gates
☐ Unbalanced cavity mold

Defect: Sink or shrink marks, voids, or bubbles

Possible causes

☐ Insufficient effective pressure in cavity
☐ Insufficient dwell time
☐ Stock temperature too high
☐ Mold temperature too low
☐ Freeze-off at gate
☐ Improperly located gate
☐ Poor part design, nonuniform sections, excess wall thickness

Defect: Brittleness

Possible causes

☐ Stock temperature too low
☐ Mold temperature too low
☐ Degraded material from cylinder
☐ Contamination
☐ Improper color concentrates
☐ Improper design, inadequate radii at corners, notch or thread design
☐ Voids

Defect: Poor welds, flow marks, poor surface

Possible causes

☐ Stock temperatures too low
☐ Improper gate location or gate design
☐ Injection pressure too low
☐ Inadequate venting
☐ Dirty cavity surface, excess mold lubricant
☐ Too fast fill

Defect: Warping, low heat distortion temperature

Possible causes

☐ Molded-in strains due to low stock temperature, mold too cold
☐ Improper design, nonuniform walls
☐ Overpacking in gate area
☐ Too long flow, insufficient gates
☐ Improperly balanced multiple gates
☐ Improper balance core and cavity temperatures
☐ Part ejected too hot
☐ Inadequate or poor location of knockout mechanism

Defect: Erratic quality

Possible causes

☐ Undersized cylinder volumetric and heating capacity
☐ Nonuniform cycle
☐ Nonuniform feed temperature
☐ Erratic performance of equipment
☐ Unbalanced multiple cavity layout and runner system

ACETAL RESINS

Defect: Short shots and/or surface pits or wrinkles

Suggested solution

☐ Adjust feed for no more than ¼ in. back-up
☐ Use maximum ram speed
☐ Use booster
☐ Increase mold temperature (as high as 250° F.)
☐ Check for plugged nozzle—one sign is unmelted material in the shots
☐ Set hopper heater 200-250° F.
☐ Increase over-all cycle time
☐ Increase cylinder temperature

Defect: Sinks

Suggested solution

☐ Use booster
☐ Increase plunger forward time
☐ Decrease mold temperature
☐ Decrease cylinder temperatures

Defect: Discoloring

Suggested solution

☐ Decrease cylinder temperature and/or over-all cycle
☐ Check temperature controls and instruments
☐ Check hold-up time

Defect: Voids

Suggested solution

☐ Use maximum ram speed
☐ Adjust feed for no more than ¼ in. back-up
☐ Increase injection pressure and use booster
☐ Increase plunger time, but keep over-all cycle constant
☐ Increase mold temperature

Defect: Warping

Suggested solution

☐ Measure mold surface temperatures for eveness on both halves; usually the hottest side results in the greatest shrinkage
☐ Decrease mold temperature
☐ Increase plunger forward time
☐ Increase injection pressure
☐ Increase mold cooling time

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[1] In severe cases it may be necessary to re-locate the gate or even decrease the depth of the obstructing letter or numeral. "Tails" can be caused by a lack of welding as the plastic flows around the raised numeral or may be caused by a tearing as the material flows over the numeral. Thus, if the defect is not eliminated by the adjustments listed, it is desirable to try cautiously raising the cylinder temperature before making mold changes.

[2] It may be desirable to use a clamping jig in which to cool the parts after removal from the mold. Annealing pieces in water at approximately mold temperature—cooler water for thin pieces, warmer water for thick pieces—is not recommended, except under carefully controlled conditions, as acrylics have a tendency to craze under these conditions.

Compression and transfer molding

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INTRODUCTION

By E. Vaill*

Compression and transfer molding are frequently considered under the one heading of compression molding. Molding of thermosetting materials was originally done by the compression technique. In this method, the material, either loose or preformed, is charged into a heated mold. The mold is closed, generally under low pressure, until the two halves of the mold exert pressure on the material. Under this heat and pressure, the material softens. As the mold continues to close, the softened material is forced into all parts of the cavity. Just before the mold is completely closed, high pressure is exerted and causes final and complete filling out of the mold. The high molding pressure is continued for the necessary period of time required for curing. Then the mold is opened, and the molded part is removed.

Transfer molding: In more recent years the transfer type of molding has come into prominence because of the advantages offered in filling intricate shapes and multiple cavities. Briefly, in transfer molding the material is charged into a pot and forced through runners into the closed mold cavity. In most cases, the material is heated prior to being charged into the pot. Pressure is applied for the time necessary for cure, after which the mold is opened and the parts removed. In this operation, a cull is usually left in the pot, and this must be removed before the next cycle.

Plunger molding: Plunger molding is a special type of transfer molding in which the material is charged into a cylindrical chamber open at one end and connected to the mold cavities by runners.

Types of material

The materials most generally molded by these two methods are alkyds, melamine formaldehyde, urea formaldehyde, and phenolics. With regard to thermoplastic types, the principal use for compression molding is in the cycled molding of rigid vinyl and styrene sound records. Transfer or plunger molding of thermoplastic materials is not extensively used in the molding trade. Recent work, however, has shown that rigid PVC can be high-frequency-preheated and plunger molded. Tetrafluoroethylene (TFE) resins find many molding applications because of the excellent thermal stability exhibited.

Preheating

Preheating of the molding material prior to charging the mold is a basic element of most molding operations today. It reduces the pressure required to mold a given piece, shortens cure time, especially where thick sections are involved, and is a prerequisite for plunger molding. In addition, preheating permits the molding of pieces with intricate or delicate inserts and, to some degree, depending on the method, dries the material to give improved electrical properties and reduced shrinkage. Of the three general types of preheating—electronic, steam, or dry-air—the electronic, or high-frequency method is most frequently used.

Electronic preheating offers the advantage of very fast uniform heating throughout the mass of material. This directly implements savings in cure time, which tend to offset the initial cost of electronic preheating equipment. The economic advantages of electronic preheating and automatic molding have been combined during the past few years into a single automatic process. In such an operation, the powder or preformed material is electronically preheated, automatically transferred to the compression or plunger molding press, and automatically molded and ejected.

Where improved electrical properties are important, dry-air preheating is of definite value because it removes moisture most effectively. It is the slowest preheating method, but it can be accomplished with simple equipment.

Steam or moist-air preheating is a simple method of preheating but is much slower than high-frequency preheating and, generally, is in very limited use at the present time. Because it introduces moisture into the material, it may also adversely affect the electrical properties of the molded part.

Compression molding

Compression molding is the preferred method for producing parts of large area or deep draw. Furniture drawers, radios, and housings for instruments, meters, office and business machines, and similar box-like structures are usually compression molded. This type of molding is also commonly employed for large-scale production of simply designed pieces

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* Technical service engineer, Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42 St., New York 17, N. Y.

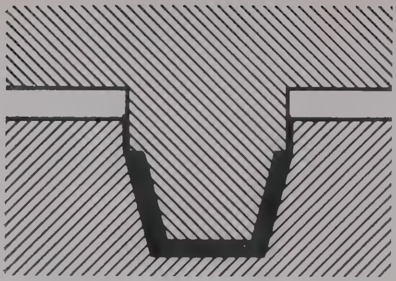


FIG. 1: Fully-positive compression mold

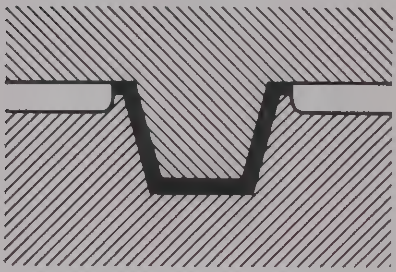


FIG. 2: Flash type compression mold

such as closures, tube bases, buttons, and wiring devices.

Compression molding is not normally recommended in the molding of intricately designed articles containing undercuts, side draws, small holes, and inserts. The flow of the material under high pressure may distort or break pins and dislodge inserts. Such parts should usually be made by plunger molding. However, the use of electronically preheated powder in compression molding appears to be overcoming most of these disadvantages and may broaden the use of compression molding.

Molds: Compression molds are generally of five different types, as discussed below.

The fully-positive mold (see Fig. 1, above), which permits almost no material to escape during molding, produces a piece of maximum density since the full pressure developed is exerted on the material. It is unsuitable, however, for use in multiple-cavity molds since it produces pieces whose dimensions vary with the charge weight.

Arrangements are therefore commonly made, by several types of cut-off, to permit the escape of excess material. In molds of the *flash type* (see Fig. 2, above), the overcharge escapes relatively easily through the narrow space between the lands as the mold closes. The pressure on the material is therefore lower and the density of the piece is less. This method of molding is inexpensive, maintains constant piece dimensions, and permits the molding of thin-walled pieces. In molds of the *semipositive* and *landed-positive type* (see Figs. 3, 4, and 5, opposite), the halves of the mold telescope to some degree, thus providing better transmission of pressure to the material than is possible in the flash type. Generally, sufficient clearance is allowed between telescoping parts to permit the escape of excess material. It should be mentioned that in any type of landed mold somewhat less than the total pressure developed will be transmitted to the material.

In fully-automatic compression molding, where poor release may constitute a serious problem, certain additional design features must be considered. Flash release in internally landed-positive molds is improved by elimination of radii in the bottom of the loading chamber and in the outer edge of the flash ring or the force. The provision of one or more flutes in the telescoping sections provides reinforcing ribs in the flash and thus facilitates its removal as a unit with the piece.

Molding methods: Molding methods may be classified according to the use of hand molds, and semi-automatic and fully automatic equipment. When hand molds are used, the mold is assembled and charged on the bench, transferred to a press, and then disassembled and discharged on the bench. This method is used only with intricate molds and for extremely short runs.

In semi-automatic molding the mold is mounted in the press, with knockout pins, and is charged and discharged manually. Presses of this type may be manually controlled or of semi-automatic operation. The greatest volume of molding, particularly of large pieces, is performed on equipment of this nature.

Several automatic machines may be run by one operator, who provides a supply of material for each machine and periodically removes accumulated pieces which have been automatically molded and discharged. This method, employed for extremely long runs of small pieces such as closures and tube bases, is gaining increased recognition because of the labor savings permitted.

Transfer or plunger molding

Transfer or plunger molding has several advantages to offer over compression molding. The filling of intricate molds or molds with long core pins or inserts is accomplished better by transfer or plunger molding. In addition, shorter molding cycles may be possible with this type of molding. There are two reasons for this:

1) The loading time is usually shorter since fewer and larger preforms are used. These can be preheated more rapidly and effectively in electronic and steam preheating equipment. (Some electronic preheaters are in use with loading boards for multiple-cavity compression molds.)

2) Shorter curing times are possible, particularly in thick sections. This is true because the material is further heated as it is forced through the gate, and the volatiles escape through vents and clearance spaces around movable pins.

Easier finishing is also possible with transfer molded articles since flash is quite thin or nonexistent. Gates can usually be made sufficiently thin, and so located, that their removal is easy and inexpensive.

There are several disadvantages of transfer or plunger molding when compared with compression molding. The material left in the pot and runners is completely reacted and must be discarded. This loss is unavoidable and can represent a sizable percentage of weight of the pieces molded.

Loss of mechanical strength with higher impact materials containing fibrous fillers may occur in transfer molding. Furthermore, transfer molding is less adaptable to the fabrication of large pieces.

Molds: Experience with different types of presses and mold designs indicates the following to be good practice. Individual hardened steel cavities should be mounted in the chase plate, which should be cored for steam-heating. Runners and gates should be hardened. The cavity and chase-plate land areas should be ground and polished to insure maximum surface contact when the mold is closed. This prevents flashing of the material from cavities and runners. The mold should be adequately supported directly under the pressure chamber to insure against distortion or sagging. If this precaution is not taken, mold distortion will result and cause flashing and nonuniform filling.

The gate to the cavity should be located on an easily-accessible surface so that its removal may be accomplished by a simple finishing operation. Care should be taken not to gate the cavity directly opposite a mold pin or other protrusion in the mold. Gating at such a point will cause material entering the cavity to divide into two or more streams, tending to cause weld marks and knit-lines and to decrease the physical strength of the molded piece. Gate size may range from pin-point to 0.500-in. wide and 0.125-in. deep. In the molding of comparatively small pieces, a gate 0.100-in. wide and 0.015-in. deep will usually prove satisfactory.

Proper venting of the mold is essential to permit the escape of air trapped in the mold prior to injection of the material. Vents should be located on the same half of the mold as the runners, at the point which fills out last. This is generally furthest from the gate, thus facilitating the sweeping out of air and preventing gas entrapment. Vents 0.002-in. deep and 1/16- to 1/8-in. wide are adequate.

Molds used in plunger molding are normally multiple cavities. However, the number of cavities possible in a plunger mold is less than that possible with a compression mold. As a rule, plunger molding is performed on semi-automatic equipment. Fully-automatic machines are being used, particularly for small pieces.

Mold and part design

In designing a part to be molded, adequate draft must be provided to permit easy removal of the piece. Corners should be rounded to avoid stress concentrations. Sections should be of uniform dimensions; nonuniform sections promote gas entrapment, warpage, and internal stresses. Where inserts are necessary, special provisions must be made to hold them rigidly in place. In calculating molded part dimensions, care must be taken to make proper allowance for shrinkage and flash cut-off. Small undercuts may be used in one of the mold halves to insure retention of the piece on that particular half of the mold. Proper design of the mold is also important from the standpoint of the particular molding material to be used. A sufficient number of steam channels or electric heating elements (depending on the method used) must be carefully located in the mold to insure uniformity of temperature.

Materials of construction: Molds machined from tool steel, although expensive, are superior to other types. Hobbing steel may be used to produce molds where a large number of cavities are to be made. Chrome-plating of metal molds provides an excellent surface, improved release properties, and increased resistance to staining.

Material plasticity

The plastic behavior of a molding material as it is molded is determined by two factors: 1) the flow properties of the material; and 2) the molding conditions. The rheological (flow) properties of the material are numerous and complex, and their complete definition would require determination not only of several rheological properties as a function of temperature, but also the time rate of change of these properties. For practical purposes, material plasticity is defined in terms of specific molding tests which roughly simulate conditions of use in the field. These ratings do not, and can not, completely define material plasticity. They do serve: 1) to predict relative performance of different materials under conditions of use; and 2) as a first approximation of relative molding performance.

It is evident that a thermosetting material with too-low plasticity may fail to fill the mold because it sets to hardness before the mold is closed. An otherwise soft enough material can do likewise if it sets too quickly. Consequently, both plasticity and reaction rate must be appropriate for the intended application and the equipment used to mold it. Too plastic a material also can cause inadequate filling of the mold due to excessive flash loss.

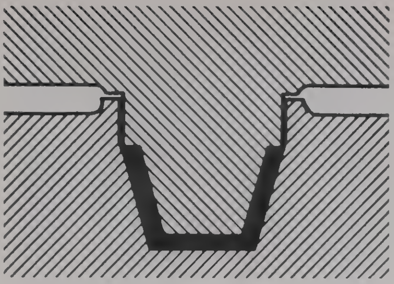


FIG. 3: Semi-positive compression mold.

The principal molding conditions which affect material plasticity are: 1) pressure on the material; 2) preheat temperature; 3) time cycle; 4) mold design; and 5) mold temperature.

Molded piece dimensions

Molded plastics parts are usually smaller than the molds themselves. This difference in dimensions, or molding shrinkage, though it may be only a few tenths of 1%, is of considerable importance when dimensional tolerances are exacting. A differentiation should be made here between molding shrinkage and so-called "after-shrinkage." The

FIG. 4: Internally landed positive mold

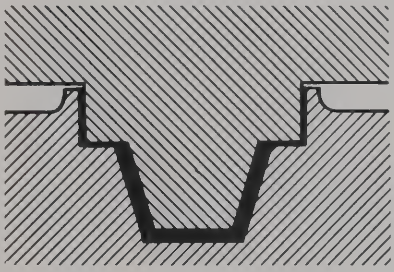
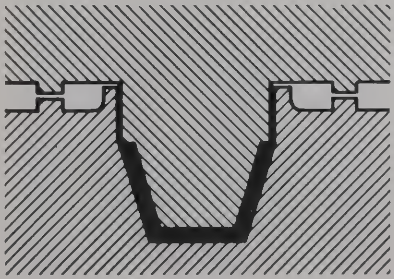


FIG. 5: Externally landed positive mold



latter usually results from exposure of the molded piece to dry environmental conditions. Under moist conditions, moldings may increase in dimension.

The mechanisms by which molding shrinkage occurs are: 1) thermal contraction, which is a function of the ejection temperature of the molded piece and coefficient of thermal expansion; 2) elastic recovery (expansion that tends to reduce shrinkage)—this depends directly on the compressibility of the material and the actual pressure exerted on it; and 3) plastic deformation, which is caused by mechanical distortion. The variables affecting these shrinkage mechanisms are molding conditions, mold and piece design, and material.

Molding speed

As with plasticity and shrinkage, molding speed can be varied greatly by altering molding conditions. The most important variables affecting molding speed are charge temperature and mold temperature. The charge temperature, or temperature of material entering the mold, is the biggest single variable for pieces of any size. It is especially important in the case of thicker pieces because the poor thermal conductivity of thermosetting materials retards heat transfer from the mold to the center of the material. Conversely, mold temperature is most important in thin sections where low charge temperatures are used.

Time, temperature, and pressure are the variables which control the cure of a thermosetting material. The effect of time is always in the same direction. Longer cure time, unless decomposition occurs, results in greater rigidity up to the point at which essentially complete reaction is attained.

The effect of molding temperature of thermosetting materials is twofold. Two opposing mechanisms take place simultaneously: (1) chemical hardening and (2) thermal softening. At low preheat temperatures mechanism (2) predominates and hence the net effect is the softening of the material. As the temperature is increased, mechanism (1) becomes dominant, and the material cures.

COMPRESSION MOLDING: Alkyds

By J. J. Moylan*

Many types of alkyd molding compounds have been developed since their introduction more than ten years ago. While the general characteristics of fast cure and low pressure requirements are common to all of these compounds, they may be divided into three different groups according to physical form before molding.

Granular materials: The physical form of materials in this group is that of a free-flowing powder. Thus, these materials readily lend themselves to conventional molding practices such as volumetric loading, preforming, and high-speed automatic operations. They have found extensive use as high-grade electrical insulation, especially in the electronics field. Typical applications are television tuner segments, electronic tube bases and sockets, ignition parts, etc.

Putty materials: This group contains materials which are furnished in soft, putty-like sheets. They are characterized by very low pressure requirements (less than 800 p.s.i.) and find use in molding around delicate inserts and in special loading problems. The molder of these types customarily extrudes the material into a ribbon of a specific size which is then cut into preforms before molding. Putty materials have found widespread use in encasing electronic components such as capacitors, resistors, small coils, etc.

Reinforced alkyd materials: Among recent additions to the alkyd family are materials which combine the molding characteristics of polyester resins with the reinforcing action of fibrous glass fillers to attain very high strength. These materials have found widespread use in such applications as insulating brackets and bases, rocker rings, circuit breakers, heavy-duty coil forms, and similar applications where high strength and good electrical characteristics are important. In many cases they have replaced assemblies of metal and insulating materials. Alkyd materials having small percentages of glass fibers, intermediate in strength properties and cost, are now available, as well as materials containing sisal and other fibers for reinforcements.

Within each of the three groups, several distinct types are available. For example, some types are self-extinguishing, some have approval under military specifications, some have improved high-humidity performance. The manufacturers' literature on these materials should be consulted before selecting a material for a specific application.

Presses and equipment

Although full realization of the advantages of molding alkyds is best attained through the use of high-speed, lightweight equipment, nearly all modern compression presses are suitable. Some presses may be encountered, however, which are so slow that it is necessary to speed the ram travel by use of a high-volume pump or to decrease the amount of travel by mounting the mold on blocks to reduce daylight. Because of the low-pressure molding characteristics of alkyds, the high-pressure line may sometimes be cut out completely and only the low-pressure side of the system used. In general, not more than 4 sec. should elapse before charging the mold and applying full pressure in the case of granular and putty types, or 8 sec. in the case of fibrous glass-reinforced material.

In selecting a press to operate a specific mold for alkyds, the following rule should prove useful: For average draws, the press should furnish about 1500 p.s.i. over the projected area of the cavity and lands for molding granular alkyds; about 800 p.s.i. for alkyd putty; and about 2000 p.s.i. for glass-reinforced alkyd.

Marked savings in labor, maintenance, floor space, power costs, and depreciation are possible through the use of presses specifically designed for use with alkyd materials. Detailed information and specifications are available directly from the manufacturers.

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* Glendale-Plaskon Laboratory, Plastics and Coal Chemicals Div., Allied Chemical Corp., 40 Rector St., New York 6, N. Y.
References were prepared by the editors.

Mold design

Alkyd parts are in successful production in positive, semipositive, and flash molds. In general, the semipositive and positive types are recommended to obtain uniformly dense parts with lowest shrinkage. Flash types, since they rely on back pressure for density, do not usually produce parts of maximum density due to the soft flow characteristics of alkyd materials. However, flash molds are frequently used with alkyd putty because of its low bulk factor. In any case, the use of polished, hardened, chrome-plated steel molds is recommended.

Positive and semipositive molds should be designed for enough freedom to allow escape of material to prevent over-pressuring. Punch clearances on positive molds of the order of 0.004 to 0.005 in. are generally recommended for the granular and putty types. Slightly greater clearances are customarily used for glass-reinforced materials. Excessive clearances are to be avoided since they reduce the effective molding pressure on the material, and thereby cause a reduction in strength.

Shrinkage

Compression moldings in the glass-reinforced types will exhibit shrinkages from cold mold dimensions in the range 0.002 to 0.004 in./in. when recommended mold clearances are used; when plunger molded, the range will be somewhat higher, depending on the plunger and clamping pressures used. The mineral-filled types, when compression molded, will exhibit shrinkages in the range 0.004 to 0.008 in./inch. (See Table I, below.)

In general, alkyd moldings exhibit little or no after-shrinkage under normal conditions of use.

Plunger molding

The use of transfer- or plunger-type molds is not generally recommended for molding putty or granular alkyd. In many such molds the plastic phase is too short to permit the material to complete its travel through the gates and runners before cure sets in. Precuring, even when it does not preclude complete filling of a mold cavity, can result in porosity, uneven density, and incomplete fusion. Such conditions obviously lead to loss of mechanical and electrical properties and to sharp deterioration in water resistance. In some cases, defects occurring in a transfer molded piece may be concealed to the eye but will show up under test or in service.

TABLE I: Compression molding characteristics of alkyds

Type	*Mold temp.* °*F.* (*suggested on 1/8-in. section*)	*Method*	*Cure time,* *sec.* (*suggested on 1/8-in. section*)	*Shrinkage* *in./in.* (*from cold mold dimensions*)	*Pressure* *p.s.i.* (*suggested over projected area*)
Mineral-filled putty (alkyd 417)	320	Compression	11	0.004-0.007	800
Mineral-filled granular (alkyd 420 & 422)	320	Compression	11	0.004-0.007	1500
Modified mineral-filled granular (alkyd 430)	325	Compression	13	0.005-0.008	1500
Glass-reinforced (alkyd 446)	320	Compression	20	0.002-0.004	2000
Glass-reinforced (alkyd 446)	290	Plunger	20	0.004-0.007	5000 Plunger 2500 Clamp

On the other hand, there are applications successfully in production on transfer molds in granular material. These transfer molds meet the following design requirements:

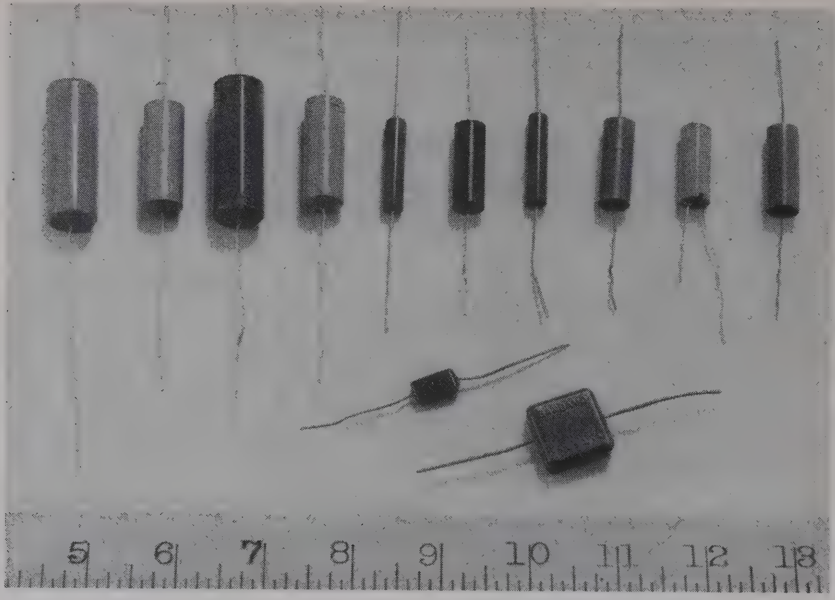
1) Relatively small pieces to be molded; 2) cavities grouped very closely to the transfer pot; and 3) very wide open runners and liberal gating.

It has also been noted that parts molded in transfer cavities gated at two locations show poor mechanical strength, especially at the weld line. In general, parts molded by either straight transfer or plunger methods are lower in mechanical strength and lower in electrical insulating properties than similar parts molded by compression molding.

Reinforced alkyd may be transfer molded but, again, the strength of such pieces is somewhat lower than that of compression molded pieces, the magnitude being almost entirely dependent on the size of the gates and the number of times the material changes direction before entering the cavity. Since these changes are dependent upon design, pieces will have to be tested individually to determine the suitability of the material for specific applications.

Gate location

Multiple gates should normally be avoided becauses of the knitting effects between gates. An exception to this is the transfer molding of circular pieces for which knitting must occur to fill the cavity. In such cases, continuous circular gating is recommended. Better strengths are usually achieved by gating at the end of the piece rather than in the middle. When shrinkage tolerances are critical, it is recommended that both transfer ram and clamping pressures be sufficient to insure dense pieces.



ALKYD PUTTY molding compounds are used for encapsulation of resistors (above) as well as capacitors, coils, etc. Because of low pressures required, even delicate inserts can be molded-in. (Photo, Allied)

To date, almost all alkyd molding has been done in molds utilizing conventional mold steels hardened by standard heat-treating methods. Other metals have been used for experimental and short-run molds. Some production molds have been chrome-plated while others are only highly polished, depending upon the preferences of the mold designer. The fact that the alkyds can be molded at low pressures has presented the possibility of using other than steel molds.

Alkyds, being mineral-filled materials, are somewhat more abrasive than general-purpose ureas or phenolics, and somewhat greater mold wear may be anticipated. Because of lower molding pressure and the greater plasticity of the alkyds, mold wear is not as great as it is with mineral-filled phenolics. The use of minimum pressures that permit satisfactory molding tends to reduce the effects of mold wear.

The usual precautions on design of pieces for thermoset molding should be followed. Particular attention should be given to the use of flowing curves and generous radii rather than sharp knife edges. Sections should not be designed in any case for less than 1/16-in. thickness, and projections and ridges should be designed with generous allowances for material.

The fast-curing characteristics of alkyd molding compounds should, of course, be taken into consideration when designing the number of cavities for a given production mold. The high production rate per cavity of these materials represents a definite savings in tooling cost.

Special considerations

Common characteristics of all glass-reinforced polyester molding compounds should be considered in designing parts. Some of these characteristics are: 1) a tendency to trap air in unvented draws; 2) a tendency toward internal porosity and internal cracking in heavy sections; 3) a tendency to crack or show poor strength when fiber alignment occurs due to flow obstruction; 4) a tendency to have relatively poor strength in thin sections; 5) a tendency to show porosity or poor end-fill on long, restricted flows; and 6) a tendency to show relatively poor dielectric strength in thin sections or in areas where fiber alignment may be normal to the conducting surfaces.

Although solutions to these difficulties may not always be possible through design alone, it may frequently be possible to avoid trouble by their careful consideration at the design stage.

Air entrapment in blind draws may frequently be overcome by venting at the top with a working pin. Sharp corners and square edges at the top of draws should be avoided in favor of radii whenever possible. It may also be possible to design the part so that the place where air may be trapped is confined to a small area where it may be easily vented.

Although the internal porosity or internal cracking frequently encountered in sections heavier than 1/4 in. may not interfere with the function of most parts, it may become a prime consideration if the section must be drilled or tapped or if electrical contacts carrying high voltage are to be molded in. In such cases, heavy sections should be avoided. Flow from thin to thick sections should also be avoided.

When the material flows around obstructions such as core pins, a certain amount of fiber alignment results. If the flow continues for a short distance beyond such points, the fibers tend to regain their random orientation and a good knit results. However, if the obstruction is near the end of the flow such as the extreme edge or top of the part, the fiber alignment may result in poor knitting or cracking. For this reason, location of core pins at extreme edges is to be avoided.

Although sections thinner than 0.015 in. may be successfully molded, the strength characteristics are quite low due to fiber alignment and fiber breakage. In general, sections greater than 0.040 in. are to be recommended.

Because of the fast-curing characteristics of the material, it may be difficult to fill parts having long flows, especially if the flow is restricted by thin sections, core pins, inserts, etc. Although loading techniques may overcome this, it is recommended that long draws be accompanied by generous sections.

Fibrous glass-reinforced materials may show good dielectric strength by standard test methods in which electrode configuration and specimen shape and thickness are carefully specified. However, in actual applications in which voltage stresses may be concentrated at sharp corners and in which thinner sections may contain nonhomogeneous areas extending from surface to surface,

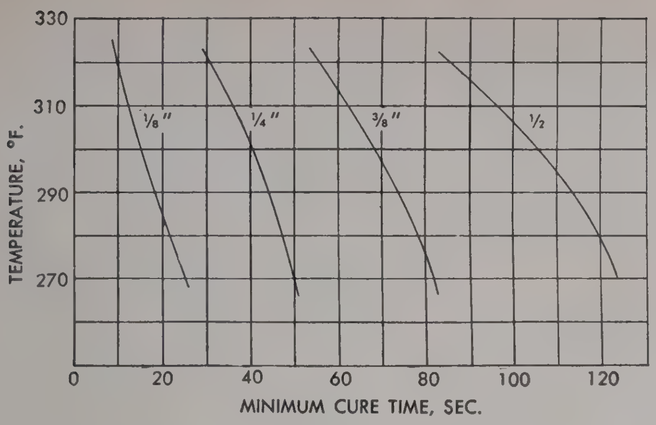


FIG. 1: Cure time vs temperature for various molded thicknesses of alkyd granular and putty materials

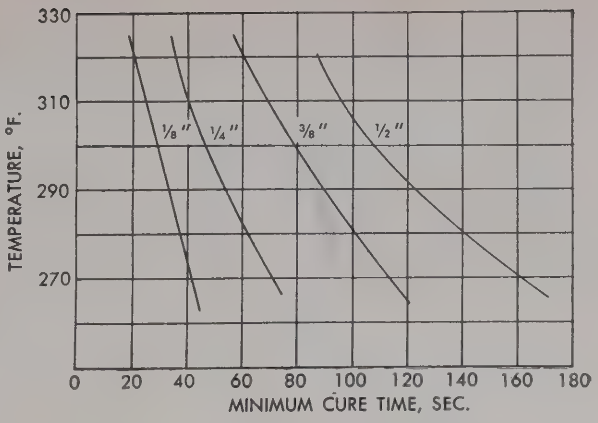


FIG. 2: Cure time vs temperature for various molded thicknesses of reinforced alkyd

glass-reinforced materials may show much lower dielectric strength.

Preheating and preforming

Although preheating of the granular or putty type is seldom necessary or desirable, reinforced alkyds are frequently preheated before weighing the mold charge to improve their handling characteristics. This is usually done in an air-circulating oven at a temperature of 130 to 140° F. for a period of 10 to 15 minutes.

It is also possible to use electronic preheating on reinforced alkyd. In this case the bulk factor is customarily reduced by either mechanical or manual compression.

Because of the low bulk factor of the granular alkyds (approximately 2:1), it is seldom necessary to preform these materials. However, they will preform with ease on conventional equipment when necessary. The preforming pressure is much less than that required for phenolic or urea materials. To avoid excessively dense preforms, it is customary to reduce the pressure of the preforming machines to about one-fourth the amount used for preforming the conventional thermosetting materials.

As previously mentioned, the putty materials are usually preformed by extrusion. Extruders of both the screw type and the plunger type are in common use. An alternate method is to roll the putty into sheets of the desired thickness, from which ribbons or slugs may be cut and used as preforms.

Because of the relatively high bulk factor of the reinforced types, some preforming is usually necessary. This is often done by simple hand compression, after warming to 130 or 140° F. Mechanical preforming methods are sometimes used and machines have recently been developed to extrude material of this type into continuous ribbons or ropes, from which preforms may be cut.

In reinforced alkyds, the shape of the preforms will have a definite effect on the flow characteristics of the material within the mold. For this reason, some experimenting with preform shapes may be necessary. In general, the preform should approximate the shape of the mold but should be somewhat smaller to insure some flow of material. Multiple preforms are to be avoided because weak sections may be encountered at the interfaces or knit lines.

Molding techniques

The resin characteristics of alkyd molding compounds are such that the material goes through the very low viscosity phase momentarily when heat and pressure are applied. This low viscosity phase makes possible the complete filling of the mold at pressures much lower than required for other thermosets.

This phase is followed by a very rapid, exothermic reaction which develops heat in excess of the mold temperature and which is responsible for the rapid cure of the material.

Since the reaction is a cross-linking polymerization, no products are given off in gaseous form; therefore, no breathing or holding is necessary.

Because the heat resistance of the material is relatively high, it is possible to leave parts in the mold at recommended molding temperatures for extended periods without risk of burning or overcure.

The most common molding difficulties experienced with alkyd molding techniques are precure of the material or use of excessively high molding pressures, or a combination of both.

Molding temperatures

The range of recommended molding temperatures extends from 270 to 330° F. In the majority of cases, mold temperatures in the range of 300 to 320° F. will be most suitable. (See Figs. 1 and 2, above.) In extreme cases, where long thin draws or slow presses are involved, temperatures as low as 250° F. have been used. However, the use of such low temperatures may tend to promote sticking, especially on mold surfaces which are not chrome-plated.

Under ordinary conditions, alkyd materials have good release characteristics and no lubrication is necessary to insure ejection from the mold. Hardened, chrome-plated steel surfaces are recommended. When sticking is encountered, it is usually due to too much pressure or too low temperature. When a mold has been running phenolic material, it is recommended that it be cleaned by running a few charges of urea or melamine before the alkyd is introduced, since the presence of phenolic resin, even in minute quantities, inhibits the cure of alkyd. Before returning a mold to the use of phenolic materials after running on alkyd, the same procedure should be followed.

In the transfer or plunger molding of reinforced alkyds, plunger pressures are largely dependent upon gate size. In general, a pressure which will bring the plunger home in about 7 sec. is recommended. However, successful cycles are in use with plunger times in the range from 3 to 12 seconds. Longer times are apt to cause precuring in transfer pot or in runners and gates.

Inserts

Because of the fact that alkyd materials have no after-shrinkage, inserts must be provided with generous knurls or undercuts to insure good gripping. Because of the soft-flow, low-pressure characteristics of alkyds, especially in putty form, many jobs involving delicate inserts have been run in these materials which could not be run successfully in any other thermosetting material.

Storage

The granular and glass reinforced alkyds are unique in that they combine high speed cure with excellent storage stability. Experience over a period of years indicates that standard storage conditions found in most molding shops are adequate. Long term exposure to temperatures over 70° F. should be avoided.

The putty types are much less stable and special refrigerated storage is usually recommended if the material is to be kept on hand for any length of time.

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Consult Directory Index and Subject Index for additional information on alkyds. See also the chapter on Alkyd Molding Compounds, p. 78.

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COMPRESSION MOLDING: Phenolics

By Edward F. Borro, Sr.*

There are two basic principles of molding phenolic thermosetting materials: 1) compression molding, described below, and 2) closed-mold molding (see p. 640).

In compression molding, phenolic resin compound in powder or preform shape is loaded directly into a hot cavity at an average temperature of 340° F. Hydraulic pressure of 2000 to 10,000 p.s.i. is applied, causing the material to flow and fill out the entire cavity.

Selecting molding pressure

Molding pressure is the pressure which is exerted on the material within the cavity and the projected mold "land" area. The required compression molding pressure for phenolic materials depends upon: 1) the type of material to be molded; 2) conditioning and preheating of material prior to molding; 3) mold temperature; 4) the design of the part; and 5) the design of the mold. Usually, semipositive and subcavity "one filling space" molds require higher pressure than flash or positive molds.

Generally, the pressure range for compression molding the various types of phenolic materials is between 2000 and 10,000 p.s.i. This, however, is a rather large range, especially when a prompt and definite decision must be made for each specific material. In many instances, insufficient pressure is available, necessitating the use of softer materials, or in some cases, the operation of the mold with fewer cavities.

Various methods for figuring the required molding pressures are used. The basic figure consists of 2000 to 3000 p.s.i. on the mold "land" projected area. This pressure is considered sufficient to mold an object using general-purpose material in "as is" condition up to 1 in. in depth. The pressure requirements for extra depth should be progressive. However, since deep parts are seldom molded from material "as is," an average of 700 p.s.i. is added for each additional inch of depth. For example, a box 3 by 3 by 1 in. deep is to be molded with ⅛-in. mold land surface. The molding area will be 10.562 sq. in. × 3000 p.s.i. Hence, 31,687 lb. force will be required per cavity. The same size box, but 4 in. deep, would require 2100 p.s.i. additional to mold the extra 3-in. depth. The total required force per cavity would be 5100 lb. × 10.562 sq. in., or 53,866 pounds.

For efficient high-frequency preheated material, the added pressure for each additional inch of depth is reduced and the pressure on a projected area is also reduced. For example, when extra-soft material is preheated to approximately 260° F., only 1000 p.s.i. is required on the projected "land" area, and 250 p.s.i. for each additional inch of depth. These recommendations are based on a fast press travel of approximately 1 in./sec. of pressing speed. The flow characteristics of thermosetting molding materials are more or less at a continually changing rate, particularly in slow-closing

TABLE I: Molding pressures for various phenolics

Grade	*A.S.T.M. molding index D-731*	*Molding pressure, p.s.i.*
Very hard	20,000	5,260
Hard	13,000	3,500
Medium	10,000	2,630
Medium soft	8,000	2,100
Soft	6,700	1,760
Very soft	5,000	1,330
Extra soft	3,600	960
Extremely soft	2,500	660

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*Supervisor, Molding Compounds, Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y.

presses. Previous tests and actual molding experience indicate that the pressure allowed for each in. of depth should be progressive as follows: first 4 in. of depth, 100 p.s.i. for each in. of depth; second 4 in. of depth, 200 p.s.i. for each in. of depth; third, 4 in. of depth, 300 p.s.i. for each in. of depth; fourth 4 in. of depth, 400 p.s.i. for each in. of depth. For the sake of simplicity, it is satisfactory to use an average figure of 250 p.s.i. for each additional in. of depth.

These pressure recommendations are only applicable to parts which have a solid bottom. In the event that an opening is to be molded in the bottom of the part, it is necessary to increase the pressure up to 50%, particularly if the mold construction is such that a thin cut-off is used over the entire opening area. Pressure requirements can be somewhat reduced when a part is being molded with a through hole, and the force can be recessed from 0.015 to 0.045 in. in depth up to approximately ⅛ in. within the cut-off edge. When this relief procedure is used, only 25% increase in pressure is necessary over an object which has a solid bottom.

TABLE II: Effect of temperature on flow and pressure

Mold temp.	*Material*	*Flow time*	*Mold closing pressure*
°F.		*sec.*	*p.s.i.*
270	as is	43	1,315
320	as is	27	1,580
340	as is	21	1,970
370	as is	10	2,450
320	preheated	10	800

TABLE III: Curing times for general-purpose phenolic

Compression cures			*Cup mold*		
Material	*Preheat temp.*	*Mold temp.*	*Hard*	*Med.*	*Soft*
	°F.	°F.	*Curing time, sec.*		
Cold powder	—	310	90	110	135
" "	—	330	85	105	125
" "	—	350	80	100	115
" "	—	365	70	95	105
R. F. powder	240	310	75	75	85
" " "	"	330	65	70	75
" " "	"	350	55	60	65
" " "	"	365	50	55	60
R. F. preforms	260	310	55	60	65
" " "	"	330	45	55	60
" " "	"	350	35	45	50
" " "	"	365	30	35	40

Phenolic molding materials are produced in various plasticities, also referred to as "flow;" hence, within certain limitations, material can be selected to fit the job. However, this does not always result in the most economical production. A.S.T.M. Method D-731 can be used to determine the required molding pressure. Table I, p. 638, illustrates the range of grades produced.

These molding pressures in p.s.i. are the minimum pressure required to close the A.S.T.M. cup mold on material in "as is" condition. The range of closing time at these pressures depends on the type of material and is generally between 26 and 40 seconds. For production design purpose and reasonably short mold-closing time, at least 50% above the stated minimum pressures should be allowed. For high-frequency-preheated material, the molding pressure in p.s.i. can be used as per Table I, or even somewhat lower if the molding equipment is fast-operating.

High-impact types of material require an average of 50% higher molding pressure than the general-purpose types. This basic recommendation applies to materials in impact above 0.6 ft.-pounds. Generally, it is practically impossible to operate a mold on high-impact materials and retain a thin fin cut-off, because the thickness of the filler itself is very often in excess of 0.005 inch. When high-frequency preheating is used, at least 30% lower pressures can be used; however, the fin cut-off may not be reduced because of the filler, as previously mentioned.

Mold temperature

Mold temperatures are closely associated with molding pressure requirements. Generally, the mold temperature range is from 280 to 380° F. The effect of various temperatures on the flow time and pressure is given in Table II, above left.

Obviously, the lower mold temperatures allow the material to flow longer. Consequently, the mold closes at much lower pressures. Using 2,500 p.s.i. for all of these temperatures, the closing time is as follows:

Mold temp., °F.	Material	Flow time, sec.
270	as is	25
320	as is	18
340	as is	16
370	as is	10
320	preheated	2

Our previously mentioned pressure calculations are based on 320 to 340° F. mold temperature range.

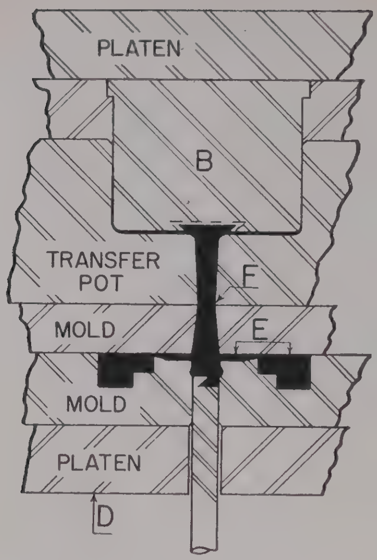
Curing time

Combination of high mold temperature and hard-flowing materials produces astoundingly fast curing results.

Curing tests, as conducted on a cup molded of general-purpose wood flour-filled phenolic, are shown in Table III, above. The results on the hard material are unquestionably the best in each instance, with highest reduction in cure on the cold powder load. The advantage of the hard material is reduced on the high-

TABLE IV: Effect of material allowance on phenolic molding cycle

Material charge	*Closing time*	*Curing time*	*Total cycle*
%	sec.	sec.	sec.
+ 2	14	46	60
+ 5	16	49	65
+10	19	56	75



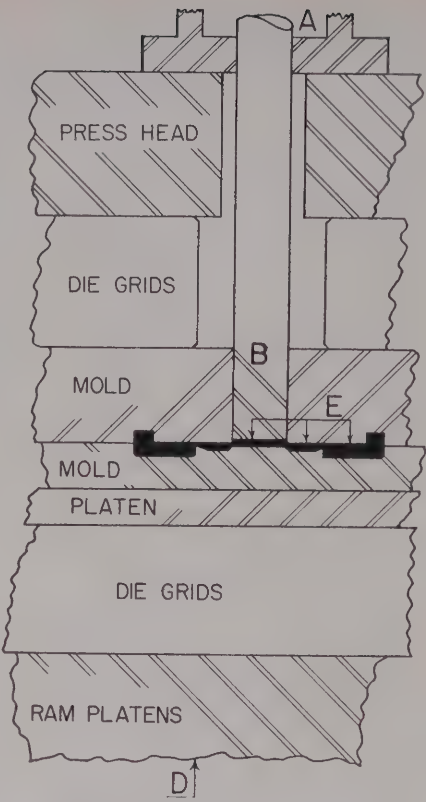


Fig. 1: B–Pot area; C–Pressure, p.s.i, on pot; D–Press pressure; E–Molding and runner area; F–Sprue diameter depends on length, should be at least 75% of runner area. B × C = D; E + 10% = B; B – 10% = E; D/B = C.

Fig. 2: A–Pressure on pot cylinder; B–Pot area; C–Pressure, p.s.i. on pot; D–Clamping pressure; E–Molding and sprue area. A/B = C; D/C – 10% = E; B × C = A; C × E + 10% = D; A/C = B.

FIG. 1, LEFT: Pot-type mold, and **FIG. 2, RIGHT:** Auxiliary ram-type transfer mold, with equations for pressures and molding areas for each

frequency preheated powder and preforms. Hard cold powder is not recommended for parts with intricate pins and mold details because of possible mold damage. The greatest curing time advantage is obtained on high-frequency preheated preforms and high mold temperatures.

The allowance of surplus material for flashing has a definite bearing on the efficiency of molding cycle. Table IV, p. 639, illustrates the results obtained on 2, 5, and 10% allowance. Close control of material charge not only saves material, but press time as well. Minimum allowance for flash and close weight control can save up to 20% in cycle time.

Shrinkage

Molding shrinkage is the difference between dimensions of the cold mold and of the molded article when measured at room temperature. In general, shrinkage varies with plasticity, molding pressure, and moisture content. Compression molded values are in accordance with the A.S.T.M. D-955 method. Some manufacturers differ slightly in respect to molding for the various plasticities to obtain more precise and reproducible results. In general, compression molding shrinkage problems are not too great if reasonable care is exercised in pressure selection for specific plasticities, mold design, and storage of material. A density-test mold measuring 1.000-in. dia. and 1.0015-in. length at room temperature, illustrates the results obtained on general-purpose, soft material in "as is" and high-frequency-preheated condition at various pressures (see Table V, below). These results obviously indicate that the material is under compression at higher pressures, causing growth of the part after ejection from the mold. The actual shrinkage of the part does not change materially from hot to cold piece.

Closed mold molding

The introduction of the pot-type transfer molding techniques in the early 1930's was considered revolutionary; full advantage of this method of molding could not be realized, however, until adequate facilities for preheating the materials were developed. With the introduction of high-frequency preheating, it was possible to reduce the molding pressures as much as ⅔ and reduce cure time by half.

The greatest improvement in speed of production was realized by combining high-frequency-preheating with plunger molding techniques. In some instances, this method of molding thermosetting materials is almost as fast as injection molding of thermoplastics.

Repeated statements have been made that there is greater dimensional accuracy and stability in parts produced by the closed mold method of molding. In most instances this is not true. Greater dimensional and warpage problems exist in these methods of molding than in the compression method. Most of the difficulties are generally traced to improper pressures, gating, plunger speed, preheating, and insufficient air venting. We are certain that runners and gates which will allow the material to enter the mold in the most fluid state will pro-

TABLE V: Shrinkage measurements on phenolic moldings

Pressure	*Shrinkage length*	*Shrinkage dia.*	*Measurement, hot piece*		*Measurement, cold piece*	
			length	*dia.*	*length*	*dia.*
psi.	*in./in.*	*in./in.*	*in.*	*in.*	*in.*	*in.*
General-purpose soft—"as is" condition, pills						
2000	.0085	.0080	1.001	.999	.993	.992
3000	.0085	.007	1.002	1.001	.993	.993
4000	.0085	.007	1.002	1.001	.993	.993
6000	.0035	.000	1.005	1.007	.998	1.000
General-purpose soft—high-frequency-preheated						
2000	.0075	.0085	1.002	1.000	.994	.9915
3000	.0085	.006	1.005	1.002	.993	.994
4000	.0055	.006	1.005	1.001	.996	.994
6000	.0055	.006	1.006	1.002	.996	.994

duce parts with minimum of strains, with uniform density, and with superior dimensional accuracy.

Clamping pressure

At least 10% extra clamping pressure must be provided to prevent the mold from floating and flashing by the hydrostatic action upon completion of transferring the material from the chamber into the cavity. When an accumulator system is used, it is advisable to exceed the 10% to compensate for the surge which is created by the fast travel.

The ratio of clamping pressure-to-auxiliary ram pressure has always been a major problem when selecting molding equipment. Hence, equipment has been purchased with various ratios which ranged from as low as 3-to-1 to as high as 8-to-1.

A study of a number of present transfer molding jobs, as well as many potential jobs, revealed a trend toward a ratio of 6-to-1, although the ratio of 5-to-1 followed closely. Since this lower ratio is required at certain times, it would be well to standardize the equipment at the 5-to-1 ratio and simplify the hydraulic equipment. For example, a press with a 3-to-1 auxiliary cylinder ratio requires a larger-diameter ram. This requires greater quantity of hydraulic fluid, resulting in higher equipment cost.

Assuming that a 300-ton press with a 60-ton auxiliary ram is purchased, a 4.38-in.-dia. transfer chamber can be used. This will supply 8000 p.s.i. transfer pressure, which is the minimum pressure recommended for high-frequency-preheated material. If 4.25-in. dia. preforms are used, quite a volume of material can be transferred. In most instances, this volume of material is far greater than can be molded with 300 tons of clamping pressure, unless the part is deep with a small projected area.

TABLE VI: Mold shrinkage (transfer molding) of phenolic

	Plunger pressure, p.s.i.				
	3000	*3750*	*6500*	*6750*	*10,000*
Impact bar,					
0.060 in. gate, shrinkage, in./in.	0.0128	0.012	0.0108	0.0094	0.0088
0.030 in. gate shrinkage, in./in.	—	0.0132	0.0124	0.0111	0.0091
Tensile bar,					
0.060 in. gate, shrinkage, in./in.	—	—	0.0077	0.0076	0.0072
0.030 in. gate shrinkage, in./in.	—	—	—	0.0081	0.0077

Figures 1 and 2, p. 640, illustrate a pot-type mold and an auxiliary ram-type transfer mold, together with the methods of calculating pressures and molding areas for each.

Gates and runners

Many widely divergent opinions are held on this subject, and no attempt will be made to discuss them here. Instead, the principal results of a rather extensive experimental transfer molding study ("Closed mold molding techniques," by Edward F. Borro, Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.) are summarized here:

1) Full-round runners offer less resistance to flow than half-round, square, or rectangular runners of the same cross-section.

2) Three closely grouped gates do not fill the cavity appreciably faster than the central one alone.

3) For a given filling time, an 8-in.-long runner requires twice as much pressure as one of the same diameter and 2 in. long. The shortest possible runners should be used.

4) As thermosets are forced to flow rapidly through small gates, the pressure drop is converted to heat in the material. This heat speeds the cure and shortens the cycle. Thus, where high transfer pressures are tolerable, small gates are usually advantageous.

PHENOLIC agitator for Norge washing machine is compression molded in two parts. Complex design of vanes increases washing efficiency

Molded density

Molded density is just one more subject which causes considerable controversy in the industry. Generally, density is associated with: 1) molding shrinkage; 2) internal stress; 3) dimensional stability; 4) warpage; 5) physical properties; and 6) molding problems. The greatest difficulties exist when the part has been compressed beyond its ultimate density.

The range between an unfilled piece and a piece molded to the

TABLE VII: Transfer (plunger) curing times for phenolic bar, ½ by ½ by 5 in., at 320° F.

	Minimum plunger pressure, p.s.i.		
	14,000	9,750	5,500
	Flow		
	Hard	Medium	Soft
	Curing time, sec.		
R. F. preforms; 265° F.; 320° F.	30	45	66
R. F. preforms; 265° F.; 340° F.	27	42	54
R. F. preforms; 265° F.; 355° F.	24	39	51
R. F. preforms; 265° F.; 370° F.	21	36	45

extreme density is very slight and is usually controlled by the selection of proper molding pressure, the plasticity of material, mold temperature, methods of preheating, and clearance in the molds. Phenolic material can be densified only to a certain point. Excessive pressures beyond this point cause expansion or growth of the molded part beyond the mold dimension.

Shrinkage in transfer molding is from 25 to 50% greater than in compression molding. For example, there is a difference of 0.004 in./in. between 2,500 and 10,000 p.s.i. The following figures show shrinkage on transfer molded general-purpose material, where the mold temperature is 320° F., high-frequency preheat on a ½ by ½ by 5 in. impact bar:

Plunger pressure, p.s.i.	Shrinkage of 5-in. dimension, in./in.
10,000	0.0084
8,500	0.0088
7,500	0.0095
6,500	0.010
5,000	0.011
4,000	0.0118
3,500	0.012
3,500	0.0124

In some instances, thick and thin section parts will shrink differently because of the speed of material reaction in the mold and cooling upon ejection. For example, shrinkage obtained on a general-purpose material molded in ½ by ½ by 5 in. impact bar and ⅛ by ⅝ by 9 in. tensile bar, using 0.030 and 0.060 in. gates are in Table VI, p. 641.

Physical properties

Physical properties obtained by the "closed mold" method of molding vary somewhat with different materials. Generally the properties are *inferior* to high-frequency preheated compression molded and *superior* to non-preheated compression molded. For example, properties of general-purpose material, compression molded non-preheated, compression molded high-frequency-preheated, and plunger molded high-frequency-preheated material are as follows:

Type of molding:	Compression		Plunger
Type of preheat:	none	H.F.	H.F.
Property			
Impact, ft.-lb./in.	0.27	0.30	0.28
Tensile, p.s.i.	7000	9000	8500
Flexural, p.s.i.	11,500	14,500	14,500
Dielectric, v./mil	400	400	400

Mica-filled materials show a slight increase in tensile and flexural strength over the compression molded properties.

Higher-impact-type materials like CFI 10 show substantial decrease in properties, particularly in flexural and impact strengths:

Type of molding:	Compression		Plunger
Type of preheat:	none	H.F.	H.F.
Property			
Impact, ft.-lb./in.	1.25	1.60	0.66
Tensile, p.s.i.	5000	6500	4500
Flexural, p.s.i.	10,000	13,500	8000

Actually, CFI 10 material becomes CFI 5 when it is molded by the closed mold method.

Curing time in transfer molding depends upon material, pressure, mold temperature, runner and gate size, and the degree to which the material is preheated. Small gates, hot preheat, high pressure, and hard material produce the fastest cures. Table VII, above, illustrates cures on "hard," "medium," and "soft" general-purpose material. The greatest saving is by combining the hard material with high mold temperature. We must remember that higher plunger pressures are required for the hard material "14,000 p.s.i." Higher pressure means smaller molding area. For example, molding 50 sq. in. in the hard material would require 350 tons clamping pressure. The same area in soft material needs 137 tons.

COMPRESSION MOLDING: Urea formaldehyde

By R. A. Tiley* and H. J. West*

Urea formaldehyde molding compounds are typical thermosetting materials, curing by chemical condensation. In the mold, the characteristic steps of flow, set, and cure are involved. The ureas are somewhat more sensitive to heat than melamines and phenolics and also generally tend to set faster in the mold; consequently, precisely controlled conditions are required to obtain good quality moldings. However, once suitable molding cycles are established, fast production schedules are practicable. In fact, the general trend in urea resin molding is more and more towards use of completely automatic presses with multi-cavity molds, often producing articles such as closures at the rate of thousands per hour.

Ureas are available in plasticities ranging from very soft flow to medium-hard flow. The stiffer materials are used for small parts such as buttons and closures; the freer-flowing materials are suitable for larger articles such as radio cabinets and other housings.

Urea formaldehyde moldings are rated as boil-resistant but not acid-resistant. A suitable test for determining whether or not a part is adequately cured is to boil a test specimen in water for 30 minutes. A well-cured molding shows no chalking or appreciable loss of gloss.

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* American Cyanamid Co., Plastics and Resins Div., 30 Rockefeller Plaza, New York 20, N. Y.

Molding conditions

Storage and handling: Urea molding compounds usually are available in powder or granular form packed in airtight, moistureproof containers. Storage under proper conditions is extremely important since heat or moisture can seriously impair moldability. It is good practice to store the containers in a cool, dry area, preferably with the temperature below 62° F. Under these conditions, urea molding compounds have excellent stability. However, material to be preformed should be allowed to warm up to at least 70° F. to promote cohesiveness; otherwise preforms may be too soft and friable.

Preforming: Many automatic molding machines operate well with the granular form, but preforms are still used for many applications. Ureas should preform well on any automatic equipment, either rotary or single-stroke. The dies should be of the highest quality steel, hardened to at least 56 on the Rockwell C scale, polished to a high commercial finish, and chrome-plated. Suggested clearances between punch and die are given in Table I, above.

TABLE I: Diametrical clearance or difference in diameter between punch and die for urea molds

Nominal size	*Clearance—upper punch*	*Clearance—lower punch*
dia., in.	*in.*	*in.*
¼	0.003	0.002
½	0.003	0.003
¾	0.005	0.003
1	0.007	0.005
1½	0.010	0.005
2	0.012	0.005
2½	0.014	0.005

NOTE: The suggested taper on the die is 0.002 in./in.

Preheating: Although more sensitive to heat than the melamines, ureas can be successfully preheated by either radiant or high frequency methods provided proper precautions are taken. Local overheating must be avoided, and material should not be preheated above 185° F. (See "High-frequency preheating of ureas," p. 137, MODERN PLASTICS, June 1957.)

A prewarming device is sometimes built into the press. One design incorporates an oil-jacketed section in the hopper discharge line. The oil is electrically heated by means of immersion heaters. Other units utilize band heaters and radiant heat.

Rotary-can type preheaters are used to advantage on bulk-loaded manually-operated presses.

Molding temperatures and pressures: The ureas are usually molded at temperatures ranging from 275 to 280° F. for large housings, to 350° F. for small parts such as buttons or closures. Molding pressures range from 2000 to 8000 p.s.i. A "breathe" early in the molding cycle often helps to promote good densification, to improve gloss, and shorten the cure cycle. A straight close, however, is preferred in the molding of small parts. Table II, p. 644, gives typical cure times and molding pressures for various parts.

Buttons and closures can be molded at high temperatures with fast cycles, since the flow involved is minor and the load in the cavity quickly reaches mold temperature. Large parts involving a high degree of flow in the mold and transfer of heat through a mass of material require a longer cycle at lower temperature.

Shrinkage: Shrinkage in urea molded parts takes place in two stages: 1) mold shrinkage—the difference between cold mold dimensions and cold molded-piece dimensions and 2) aging shrinkage—the continued dimensional change which takes place in the molded part over a period of a year or more.

One procedure for determining the shrinkage of a material is to first mold a 4- by ⅛-in. disk from the test material. The disk is allowed to cool to room temperature and then the diameter of the piece is measured. This diameter is compared with the diameter of the cold mold and is reported as CMCP shrinkage. The designer can always compensate for this difference in designing his mold.

The disk is then subjected to a temperature of 220° F. for 48 hr., allowed to cool, and the diameter again measured. The difference between this measurement and the CMCP diameter is reported as additional or aging shrinkage. This value is reasonably indicative of probable shrinkage over a three- to five-year period. Additional compensations can be made by the mold designer to allow for this dimensional change.

Since these shrinkages are determined over flat, uniform section parts, the values are useful only as guides for tool dimensions when varied wall thicknesses, holes, bosses, and unsupported sections are included in the design of the part. All of these will have varied effects upon shrinkage and cannot be predicted.

Mold shrinkage CMCP for ureas usually ranges from 0.006 to 0.009 in./in. and the additional shrinkage after 48 hrs. at 220° F. usually ranges from 0.006 to 0.012 in./inch.

It is general practice for designers to use in their molding design a shrinkage range of 0.008 to 0.010 in./inch. The allowances should be toward the lower limit for outside dimensions and high for inside dimensions.

Problems caused by after shrinkage can be minimized by good design of the molded part.

Part and mold design

Compression molds can be positive, semipositive, or flash types. The semipositive type is generally preferred although flash types are satisfactory for molding small parts such as but-

TABLE II: Approximate molding conditions for urea pieces

Part	Area projected sq. in.	Draw in.	Section thickness in.	No. of parts per lb. of material	Mold temperature °F.	Molding pressure tons per cavity	Cure time min.	Type of mold
Buttons	¼-2	—	3⁄32-5⁄32	150-1000	310-340	½-3	⅓-1	Flash
Closures	½-5	½-1	1⁄32-5⁄32	30-200	300-350	1-9	⅓-2	Flash or semipositive
Wall plates	15-25	—	3⁄32-⅛	12-20	310-320	20-35	½-2	Flash or semipositive
Razor housings	8-12	¾-1	1⁄16-⅛	10-20	300-315	15-25	2-3	Semipositive
Housings (small)	25-40	2-4	3⁄32-⅛	1-3	280-315	50-100	2-4	Semipositive
Housings (large)	70-200	5-9	⅛-3⁄16	1-4 lb. per piece	280-305	150-1000	2½-5	Semipositive
Lighting reflectors (large)	200-400	3-10	5⁄64-7⁄64	1-4 lb. per piece	280-305	600-1500	3-5	Semipositive

tons. The most important features in design are those intended to offset stresses set up by differences in shrinkage, flow, and cure. Careful design of the molded part can minimize the effect of such differences.

Openings or slots in the molded piece should be so positioned as to minimize flow differences as much as possible. Metal inserts must be thoroughly anchored in the die and should always be placed where there is an abundance of material in the part. The best practice provides for a boss diameter of three times the insert diameter, with anything less than a 2:1 ratio being definitely inadvisable.

Wall dimensions should be as uniform as possible, particularly around the openings. Differences in wall thickness can cause different degrees of cure and the resulting stresses can cause warping or cracking during service of the part.

Obstructions to flow must be avoided as much as possible and sharp-cornered right angles should be avoided, since they give rise to eddying, resulting in flow marks and nonuniformity in strength.

Because of the effect of after-shrinkage and seasonal changes in dimensions, threads on closures should be made as deep as possible to provide satisfactory thread engagement, in case of swelling or shrinkage.

Adequate clearance should be provided at mounting holes to allow for movement caused by dimension changes in the molded part.

Typical applications

Following are some general rules for molding the more popular types of urea applications. Other end-products comparable in size to the product categories listed below will follow the same general molding pattern.

Buttons: Urea molding compounds are particularly useful for molding buttons. Using a stiff, fast-cure material, extremely fast molding cycles are possible. Fully automatic flat-bed presses can be used with molds having 288 or more cavities. Small, flat preforms are generally used, which can be made from either granular or fine powder material. Cure temperatures are generally relatively high, ranging up to 350° F.

Fine powder material is often preferred for the following reasons: 1) lower initial material cost; 2) the possibility of coloring the material in the shop by ball-milling or micropulverizing with appropriate pigments, a procedure which eases inventory problems for the molder; and 3) greater ease of developing special decorative effects such as swirls, mottles, spatters or other patterns.

Finishing of buttons is generally done by first tumbling to remove the flash, then clearing the holes with a special broaching machine sometimes designed by the molder, and finally tumbling for polish.

Closures: Closure molding is almost an industry by itself. The parts are often molded on fast, completely automatic presses using either ball preforms or bulk loading. The force plugs in these presses are sometimes designed to unscrew the closure automatically. As the press opens, the plugs rotate by means of a rack and pinion and serrations in the cavities prevent the caps from rotating with the plugs. Smooth wall closures are held in place by the use of out-of-round cavities. Rubber fingers complete the unthreading of the pieces. The closures drop into a catch pan and are blown or pushed out of the press; a loading board moves in from the opposite side of the press to recharge the cavities.

Specially designed rotary presses are also used. These basically are rotating tables with self-contained, cam-operated molding units located on the periphery. Units can run to 30 or more.

As the table rotates past static

loading and unloading stations, the individual molds 1) open, 2) discharge the molded part, 3) receive a new charge of molding material, and 4) close. The cure is completed as the mold makes a complete cycle back to the first stage.

The part is usually unthreaded at the unloading station by means of a rubber wheel or belt, although in some cases the part is stripped. If stripping is intended, the molding material should be of a grade selected to have sufficient resilience for stripability.

This type of press is adaptable to molding small parts other than closures such as wiring devices and tube bases. Its advantages are relatively low tool costs, good molding speed, and ease of changing molds.

Stiff, fast-curing material is generally used for molding closures. As with other small parts, molding temperatures can be relatively high, ranging from 320 to 350° F. Mold cycles should be kept as short as possible without undercuring the part. Undercure is often evidenced by blisters. Increasing the cycle a few seconds beyond the blister point generally eliminates blisters and gives a satisfactory part.

A straight close cycle is preferred and used in most molding operations. However, some presses are valved for breathe cycles. In any case, the press should have a controlled rate of close for uniformity of production.

Electric wiring devices: These include parts such as switch triggers and multi-wall plates. Frequently they are molded on automatic and semi-automatic flat-bed presses as well as automatic rotary presses. Because of the irregular shape and design, with features such as internal bosses and rigs, relatively free-flowing material should be used. Materials classified as general-purpose with medium flow are considered to be satisfactory.

Typical molding temperatures range from 300 to 325° F. Prewarming the material is advantageous, particularly in molding larger wiring devices.

Housings: Large flat-bed presses ranging from 200 to 500 tons capacity are generally used for the molding of relatively large parts, such as radio cabinets and other housings. Because of the size of the part and the deep draws usually involved, material with a long period of flow should be used. Grades classified as soft or even very soft may be required and some manufacturers offer a special grade designated as housing material.

Because of the heavy cross-sections often involved, it may be necessary to keep the molding temperature as low as 280° F. with extended cure times.

The molding of these large parts is facilitated by the use of preheated molding material.

COMPRESSION MOLDING: Melamine formaldehyde

By H. J. West*

Transfer or plunger molding, as well as straight compression molding, generally can be used with melamine molding materials, with the exception of certain impact grades, for which straight compression molding is recommended.

Most types of melamines are available in granular form. In general, with the exception of the impact-types, they can be preformed on automatic equipment, either rotary or single-stroke. Impact-types are usually hand-preformed.

Although it is good practice to store melamine molding compounds at temperatures below 70° F., the material should be allowed to warm up to at least 70° F. before charging the mold or preform machine. Use of too-cold material may cause unsatisfactory preform hardness.

In general, dies used for preforming melamine molding compounds should be of the highest quality steel hardened to 56 on the Rockwell C scale, polished to a high commercial finish, and hard-chrome-plated. A taper of 0.002 in./in. of the diameter (0.001 in./in. of side) is desirable to ease ejection and prolong the life of the dies. Liberal clearance is desirable between top punch and top of die dimensions.

Preheating is strongly recommended to obtain the shortest molding cycle and to produce parts with optimum properties and best appearance. High-frequency preheating is most commonly used and generally gives the best results, although melamine molding compounds can usually be preheated by any accepted method.

When high-frequency preheating is used, preforms give the best results, but granular material can be used if the granules are placed to a uniform depth in a shallow polyethylene, polystyrene, or glass container. Variations in depth will result in nonuniform temperature in the charge. Because of the nonpolar nature of the thermoplastic containers, they themselves do not heat up appreciably in the high-frequency field. Rag-filled materials can be shaped by hand and placed between the electrodes.

There is a normal variation in the thickness of preforms which cannot be avoided. If preforms of different thicknesses are placed side by side in an electronic preheater, they will not heat uniformly. One way to avoid this is to stack the pills during preheating but the ideal situation is the employment of square or rectangular preforms which can be placed on edge, thereby eliminating the thickness variation. This is particularly advantageous when multiple pills are required.

The recommended temperature ranges for the preheating of melamine molding compounds are given in Table I, p. 646. The preform has usually reached a satisfactory temperature when it begins to swell and a small fracture appears at the periphery.

Rotary-can preheating is usually less efficient than the high-frequency method but good results can be obtained if proper

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*Plastics and Resins Div., American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y.

References were prepared by the editors.

TABLE I: Preforming, preheating, and molding melamine

	Filler					
Property	*Cellulose*	*Asbestos*	*Wood flour*	*Fabric*	*Glass fiber*	*Unfilled*
Preformability	Good	Good	Good	Hand preforms only	Single-stroke machines	Single-stroke machines
Preheating temp. range, °F.	220-250	220-250	200-250	200-230	220-235	200-230
Molding temp. range, °F.	310-340	310-330	310-330	300-340	290-320	300-340
Molding pressure range, p.s.i.	1500-6000	1500-6000	1500-6000	4000-8000	2000-6000	2000-4000
Transfer molding pressure range, p.s.i.	6000-20,000	4000-12,000	6000-12,000	8000-12,000	8000-12,000	Not recommended
Mold shrinkage, 4 × ⅛-in. disk, mils/in., A.S.T.M. D-1299-53T, modified	6-9	5-7	7-8	3-4	2-4	11-12
After-shrinkage, mils/in., 48 hr. at 220° F. A.S.T.M. B-1299-53T	6-10	2-3	5-6	4-8	4-6	7-12

care is exercised. The containers must be carefully cleaned between heats to prevent overheated material from contaminating any of the subsequent charges.

Molding

Melamine formaldehyde molding compounds are thermosetting, and in the molding operation pass through the characteristic stages of flow, set, and cure. Volatile material, principally water, is liberated during the molding cycle and must be allowed to escape from the mold as completely as possible in order to obtain the best results.

Straight compression molding, preferably employing semipositive molds, is generally used in the production of parts with large area such as dinner plates, or with deep draw, as in tumblers or cups. Also, large housings, including radio and meter housings, are usually compression molded. Melamine molding compounds are well-suited to fully automatic compression molding of small articles such as buttons and closures.

In straight compression molding, it is important to insure that the material in the mold is uniformly heated throughout before closing the mold. The use of too stiff a material or too high a mold temperature can cause lack of homogeneity in the molded part. Preheating is usually the most effective method of promoting uniform heating throughout the charge. In the molding of material that has not been preheated, it is desirable to subject the material to a preheat cycle in the mold. This involves partially closing the mold and holding it for a short time before completing the closing cycle. Additional comments on molding variables are given below.

Melamine resins are considerably less critical than urea resins in regard to temperature and duration of cure, resembling the phenolics more closely in moldability. It is relatively easy to impair the properties of ureas by overcure or burning, whereas because of much better heat resistance, melamine resins are much less sensitive to overcure.

Typical cure times for five types of melamine molding compounds are given in Table II, p. 647.

Buttons and closures can be molded at high temperatures with fast cycles since the flow involved is of minor degree and the small cavity charge quickly reaches mold temperature. The molding of large pieces involves a high degree of flow in the mold and the transfer of heat through a mass of material is best accomplished with a longer cycle at a lower temperature.

In the final analysis, a cure cycle should be worked out for each part involved since the cycle and temperature that will give the best results depend on the size and design of the part as well as on the type and grade of melamine molding material used.

A "breathe" at least once during the molding cycle is often desirable, particularly with large moldings. This is accomplished by opening the mold while the charge is still plastic, holding it open for a second or two, and then completing the molding cycle. The "breathe" promotes removal of the volatiles liberated during cure.

The molding pressure required depends on several factors which include the size of the part, the depth of draw, whether or not the material has been preheated, and the flow or plasticity of the material being molded. Typical compression molding pressures usually range from 1500 to 5000 p.s.i.

Transfer molding

Transfer molding is indicated when the molded parts call for the following features: Molded-in metallic inserts. Intricate shape (e.g., cups with intricate handles). Maximum strength and uniform density.

Preheating of the material is particularly desirable in transfer molding.

In plunger molding, a modified transfer molding method, much faster molding cycles are obtained than with the older transfer methods. Adequate preheating is almost essential.

Relatively free-flowing materials are generally desirable for transfer molding, and the choice of a suitable grade of melamine molding compound for a specific operation should be discussed

TABLE II: Typical cure times at various temperatures for melamine molding materials[1]

Grade	*Temperature*	*Cure time*	
	° F.	⅛-in. disk	¼-in. disk
Alpha-cellulose-filled	310	90 sec.	2 min. 15 sec.
	320	60 sec.	2 min. 00 sec.
	340	50 sec.	1 min. 50 sec.
Cotton fabric-filled	300	3 min. 30 sec.	4 min. 15 sec.
	320	2 min. 45 sec.	3 min. 30 sec.
	340	2 min. 00 sec.	3 min. 00 sec.
Modified melamine—alpha-cellulose-filled	310	2 min. 00 sec.	3 min. 00 sec.
	320	1 min. 45 sec.	2 min. 45 sec.
	330	1 min. 30 sec.	2 min. 30 sec.
Mineral-filled	310	1 min. 45 sec.	2 min. 30 sec.
	320	1 min. 30 sec.	2 min. 15 sec.
	330	1 min. 00 sec.	2 min. 00 sec.
Glass-filled	300	1 min. 05 sec.	—

[1] Data are based on 4-in. disks of ⅛- and ¼-in. thickness compression molded of cold granular materials.

with the supplier of the molding compound.

Transfer or plunger molding usually require pressures on the transfer pot ranging from 4000 to 20,000 p.s.i.

Flow characteristics

The degree of flow of the molding material under molding conditions is an important factor. It has a bearing upon the kind of molding that can be made, the quality and properties of the molded part, and the type of mold that can be used. Flow must continue until the mold is completely filled out under maximum pressure. Small parts of simple design are best molded with stiff material. Large objects require the use of easy-to-flow soft grades that will fill out the mold before the material sets. Fast-curing stiff grades usually cannot be transfer molded, as set can occur before the material is completely transferred from the transfer chamber.

The alpha-cellulose-filled melamine formaldehyde molding materials are generally supplied in varying grades of plasticity designated as soft, medium, or hard.

Impact materials normally are available in a general-purpose plasticity.

The industrial grades of melamine formaldehyde molding materials, comprising wood flour-filled material and mineral-filled types are often used for molding parts for the electrical industries. Many of these industrial parts are of intricate design with metal inserts and are usually transfer molded.

Shrinkage

Shrinkage always accompanies the cure of thermosetting materials. It occurs in two stages—during the actual molding operation and during the subsequent aging of the molded part in service. The two stages are known as mold shrinkage and after-shrinkage. The latter is mainly caused by continued loss of moisture or drying out of the part, and continues until the moisture content is in equilibrium with the ambient relative humidity. Even then, dimensional changes can still occur through absorption of moisture under cool, damp conditions followed by drying under warm, low-humidity conditions.

Typical shrinkage ranges for five types of melamine molding compounds are shown in Table I, p. 646. The values shown are given in mils/in. based on a 4 × ⅛-in. molded disk. The degree of shrinkage varies with the influence of each of the following five factors:

1) *Type of material:* Shrinkage varies widely according to the type of melamine formaldehyde molding compound used. The alpha-cellulose-filled unmodified melamine materials show the highest mold and after-shrinkage, whereas relatively low shrinkage is obtained with mineral-filled and impact types. For example, a typical asbestos-filled material gives a combined mold and after-shrinkage of approximately 7 mils/in. and shows extremely good dimensional stability under environmental changes.

2) *Plasticity of materials:* Shrinkage generally decreases with stiffer flow since more of the chemical change has been effected in the material before molding.

3) *Preheating:* Preheating aids in removing volatiles before molding, thereby reducing shrinkage. This is particularly important when using soft material for transfer molding. Preheating helps in holding after-shrinkage within a normal range.

4) *Method of molding:* Ample breathing of the mold permits escape of volatiles and may reduce after-shrinkage.

5) *Design of the molded piece:* Adverse effects caused by shrinkage on aging can be minimized by good design of the molded part. Nonuniformity of thickness in a molded piece tends to produce unbalanced shrinkage and consequent warpage. In the design of a piece in which adjacent thin and thick sections are necessary, generous fillets should be used in order that the change in dimension will not be abrupt. Thus, the best design is one in which walls are uniform. The after-shrinkage ranges given in Table I, p. 646 are roughly equivalent to dimensional changes after 3 to 5 yr. at ordinary temperatures. The values can only be used as a guide for tool dimensions when varied wall thicknesses, holes, bosses, and unsupported sections are included in the design of the part. All have varied unpredictable effects upon shrinkage. The allowances should be low for outside dimensions and high for inside dimensions. Final dimensional adjustments can be made after the mold is built and before final polishing and plating.

Material with high shrinkage on aging should not be used with large metallic inserts or when the part is to be used in an assembly which would prevent the release of strains set up in shrinkage.

The foregoing considerations apply equally well to all grades of melamine molding compounds, but additional precautions are required for the glass-filled grades. Because of outstanding electrical and mechanical properties, glass-filled materials are finding increasing industrial acceptance, but they are somewhat more critical to mold. Careful mold cycling is essential to obtain parts with optimum properties.

The glass-and-melamine resin compound has these unusual characteristics: 1) the resin does not impregnate glass fibers; 2) during molding, only the resin softens and flows; and 3) the resin can flow away from the glass during molding, giving sections without reinforcement in the finished piece.

To minimize problems caused by this behavior, the following procedures are suggested: a) molding pressures should be 2500 to 3500 p.s.i., as excessive pressure contributes to resin segregation; b) mold temperatures should range between 280° F. for large parts and 320° F. for small parts; c) straight-close cycles should be avoided; d) high-frequency heating should be used whenever possible; and e) time of cure should not be appreciably longer than that necessary to give a blister-free part.

Glass-filled materials may have to be hand-preformed although the granular grade can be preformed on commercial automatic equipment with adequate care. It is most advantageous to use high-frequency preheating and to preheat as hot as possible. The mold should be "breathed" at least once to eliminate volatiles. These precautions should lead to the production of good molded parts. A good molding will show a uniform grayish color and show no spotting or staining when it is subjected to various types of ink or dye solutions.

References

For further information on melamine, see p. 75; on compression and transfer molding equipment, p. 631. Also consult the Subject Index and the Directory Index, p. 1078.

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COMPRESSION MOLDING: TFE resins

By Paul E. Thomas*

Tetrafluoroethylene (TFE) resins exhibit excellent thermal stability and an unusual retention of physical properties up to temperatures approaching the crystalline melting point. TFE resins are unique in that they do not melt and flow as do conventional thermoplastics. When heated above 621°F. (327°C.), the resin undergoes a transition from its normal crystalline solid state to an amorphous gel state. In this gel state, particles of TFE resins fuse to give a structure of good strength. Based upon these characteristics, a number of processing techniques have been developed, which consist essentially of a cold-forming operation (preforming), followed by baking (sintering), and then cooling—as in powder metallurgy and molding ceramics. General molding conditions are given in Table I, p. 649.

Molding resins

There are three TFE resins that are commonly used in molding (Table II, p. 649). These resins have somewhat different molding characteristics and are generally used in different applications; Type I, a general-purpose resin, may, however, be used in all applications. Although TFE resins are not hygroscopic, it is advisable to store powders of TFE resin in a relatively dry atmosphere and at a temperature of from 70 to 90° F. This prevents condensation of atmospheric moisture onto the surface of the powder.

Resin which has become wet can be dried in trays filled to a depth of 1 in. and exposed for 1 hr. in a circulating-air oven at a temperature of 300°F.

Equipment

The major pieces of equipment needed for molding fall into two categories: presses and ovens. In general, standard compression presses have proven entirely adequate for parts in which the molding powder is manually loaded into the die. For maximum flexibility of operation, presses should preferably be equipped with ram speed controls that permit mold closing rates of 1 to 100 in. a minute. For many small parts, such as packings and seals, automatic tableting presses similar to those used with powdered metals and ceramics are commonly employed for preforming. Both mechanical-toggle action and relatively fast-acting hydraulic-type tableting presses have proven satisfactory. Special feed hoppers and loading boxes to facilitate uniform loading of the powder in the die are available from several prominent tableting-press manufacturers.

Both electrically-heated and indirect gas-fired ovens can be employed for sintering. In general, forced-draft electrically-heated ovens are preferred. Ovens for sintering should be capable of maintaining temperatures in the range 600 to 750°F. to within ± 10°F. of the oven set point. For some operations it is desirable both to heat and cool parts relatively slowly. Ovens equipped with cam-programmed controllers have proven useful in this regard.

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*Polychemicals Dept., E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.

TABLE I: Compression molding conditions, TFE resin*

Thickness of section	*Less than ⅛ in.*	*⅛ to ¼ in.*	*Over ¼ in.*
A. Preforming			
Temperature, °F.	75-300	75-300	75-300
Time, sec.	2-60	2-60	2-300
Pressure, p.s.i	3,000-10,000	3,000-10,000	2,500-8,000
B. Sintering			
Temperature, °F.	680-720	680-720	680-720
Time, min.	30-90	60-120	120 + 1 hr. for each ¼ in.
C. Shrinkage allowance, mils/in. (perpendicular to compression for free cooled parts)	5-50	5-50	5-50

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*Based on Teflon 1, the general purpose TFE-fluorocarbon resin.

Preforming

The weight of powder placed in the mold controls the thickness of the finished piece. Therefore, when close tolerances are needed, it is necessary to maintain a constant weight load. Otherwise, volumetric loading devices may be used.

Screening the resin just prior to loading improves the powder flow and reduces the tendency to "bridge" in a narrow die cavity. A sieve in the size range from U. S. Sieve number 6 to 10 is suitable. To produce a part which has a uniform density and shrinkage throughout, the powder must be loaded into the die cavity so as to give even distribution, and then leveled, all before compression. After one charge has been compressed, a charge should not be loaded into the die because a fracture line will often result between the first and second loadings. This fracture will not weld during the sintering operation unless the piece is sintered under pressure, as in the case of ram extrusion.

Compression: It is important to avoid entrapment of air in the preform during the compression period. Air entrapment is more likely to occur in preforming large pieces. It can be avoided by closing the mold slowly. Too rapid application of pressure may cause cracks perpendicular to compression.

Preform pressures depend upon the size, shape, and complexity of the molded article as well as the type of molding powder. For instance, preform pressures as low as 1000 p.s.i. are feasible when molding flat sections from Teflon[1] 7 TFE-fluorocarbon resin. On the other hand, Teflon 1, the general-purpose molding powder, usually requires preform pressures on the order of 4000 to 8000 p.s.i. for best results. In general, the highest preform pressure which does not produce objectionable flash or fractures in the finished article should be used.

When the preform is to be 3 in. or more in length, it is advisable to apply pressure from both the top and bottom of the die to minimize pressure decay and obtain uniform density.

Sintering

Preforms are usually sintered in ovens set at 680 to 720° F. Sintering times can be estimated from Table I for parts that are not sintered in a mold. When parts are sintered in a mold, longer times are required. These times can be estimated from the following relationship: Sintering time (hr.) = 3.5 (R-R′), where R is the inner radius of the mold and R′ is the radius of a core or mandrel, in inches.

Large moldings should be heated slowly (30 to 100° F./hr.) in the region of the transition temperature, 621° F. If the preform is heated too rapidly, nonuniform expansion will cause strains, which may produce cracks in the piece.

Since temperatures above 740° F. may have a deleterious effect on the physical properties of the molded part, care should be exercised to avoid prolonged exposure to excessive sintering temperatures.

Cooling

Molded parts are cooled from the sintering temperature by cooling free of any mold, or under pressure in a mold.

The rate at which a molded part is cooled from above the crystalline melting point of 621° F. to temperatures of 575° F. influences both properties (1)[2] and the final size and shape of the molding (2). In general, rapid cooling of a molded piece gives less shrinkage, lower density, but greater distortion. Distortion and

TABLE II: Molding characteristics of TFE resins

Tetrafluoro-ethylene resin	*Typical applications*	*Approximate compression ratio*	*Typical preform pressures, p.s.i.*
Type I[1] (Teflon 1)	Seals, packings, rod, complex shapes	4:1	2500-10,000
Type II (Teflon 5)	Sheet, tape	5:1	2000-6000
No A.S.T.M. designation (Teflon 7)	Sheet, tape	7:1	1000-4000

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[1] A.S.T.M. Specification D-1457-56T

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[1] Trademark of E. I. du Pont de Nemours & Co., (Inc.)

[2] Numbers in parentheses link to Special References on p. 651.

TABLE III: Coining TFE—why and how

Reasons for coining	*Example*	*Temperature of coining mold*	*Coining pressure, p.s.i.*
To increase the final density of a molding	Large sheets	Cold	1000-2000
To mold diaphragms or other thin shapes	Diaphragm	500-600°F.	1000-2000
To produce complex shapes	Molding with undercut	Cold	5000-20,000
To improve tolerances	Precision part	Cold	2000-5000
To form glossy surfaces	Sheets	Cold	200-2000
To produce straight sides in large moldings	Cylinders for skiving tape	720°F., initial, cooled to less than 300°F. on ejection	1000-2000

dimensional tolerances can be more accurately controlled by slow cooling, from the sintering temperature to about 575° F., giving greater, but more uniform, shrinkage to the molding.

Molding without coining

The following procedure is commonly employed for many small parts, such as ring packings:

1) Sift the resin directly into the die shell (U. S. Sieve Size 6 to 10); distribute powder uniformly throughout mold cavity.

2) Insert the top-end plate and compress to about 4000 p.s.i. (Pressure between 1000 and 10,000 p.s.i. may be used, depending on resin and end-product requirements.)

3) Remove the piece from the mold and sinter 1 hr. at 720° F. for each ¼ in. of the greatest thickness.

4) If flat surfaces and close tolerances are important, cool from 720 to 575° F. at a rate not greater than 45° F./hr., and then remove from oven. If slight distortion is acceptable, the part may be removed from the oven without controlled cooling.

Pieces preformed at 4000 p.s.i. and cooled at 45° F./hr. will shrink about 4% in the dimension perpendicular to compression. A similar piece cooled in air would shrink about 0.7 percent. Shrinkage at various conditions can be predicted (3).

Coining

Coining is a technique of cooling under pressure in a mold. As shown in Table III, above, pressures range from 200 to 20,000 p.s.i. depending on the objective of the coining operation. Coining times depend on the thickness of the part and may vary from 10 sec. for a 10 mil thick seal to several hours for parts with a 4-in. thick wall.

Pieces after coining will shrink appreciably during the first hour but will not reach complete equilibrium for at least three days. It is difficult to exactly predict this shrinkage, but an approximate value of 1.5 to 2.5% can be used as a guide. Parts preformed and coined at high pressures will shrink less than parts processed at low pressures.

Mold design

Good practice in mold design for TFE resins is similar to that used for thermosetting materials or powdered metals. For ordinary preforming at room temperature, the materials of construction are not critical. However, for accurate work, materials which can be hardened without distortion are recommended. When molding cylinders of TFE resin, the die shell and mandrel should be harder than the end plates to prevent galling. The molds used to fabricate the common shapes of TFE resins are simple.

Preform molds: The cavities of preforming molds must be designed with sufficient volumetric capacity to compensate for the compression ratio and variation in bulk density of the resins. The approximate compression ratios are shown in Table II, p. 649.

The clearance between the end plates and mold walls depends upon the amount of flash that can be tolerated. Radial clearances of 0.001 to 0.004 in. are generally satisfactory.

In preforming, it is difficult to force powders of TFE resins to flow. For molding complex shapes, this resistance to flow must be considered, and molds should be designed to minimize the requirement for flow, and to permit uniform compression on all sections of the preform. Spring-loaded molds and molds with telescoping sections are helpful in this respect.

The shrinkage of a piece during molding must be considered in designing the preform mold. Having determined the desired process condition, the shrinkage can be predicted. (See discussion on shrinkage in the preceding paragraphs under the heading "Molding without coining.")

Molds for coining: Molds such as coining molds which come in contact repeatedly with hot TFE resins should be chromium-plated (about 0.003 in. thick) to prevent corrosion. If the molds are to be used for a limited number of pieces, the application of a silicone varnish (such as Dow Corning Silicone Varnish DC-993) to the surfaces of the mold may prove more economical than chromium-plating.

Shapes that are flexible or tapered can be placed in the coining mold with no difficulty. For pieces with straight sides, a slight taper on the upper part of the

TABLE IV: Mold dimensions for TFE rods and tubes

Desired O.D. of piece, in.	*I.D. of mold*
1½ to 5	⅛ in. larger than O.D. of piece
5 to 10	¼ in. larger than O.D. of piece
10 to 15	½ in. larger than O.D. of piece

TABLE V: Suggested conditions for optimum TFE properties

Property	*Preform pressure*	*Desired crystallinity*	*Cooling rate*
Flexibility	Minor effect	Low	Rapid
Stiffness	Minor effect	High	Slow
Flex life	Maximum	Low	Rapid
Dielectric strength	Maximum	No effect	No effect
Resiliency	Minor effect	Low	Rapid
Impermeability	Maximum	High	Slow
Ultimate strength	Maximum	Low	Rapid

coining mold will facilitate the entrance of the piece into the actual cavity. Sometimes the die blocks are cored for cooling or heating. The shrinkage of the part after coining must be considered in designing the coining mold. (This shrinkage is discussed in the section on coining.)

The size of the preform mold required for a coining procedure can be determined by the use of slugs machined from stock which was molded at the selected preform conditions. Following a trial-and-error procedure, a slug is machined, which, when heated to 680 to 720° F., would fit the coining mold. Then the preform die is designed so as to produce this slug.

The preforming die should be smaller than the coining die, since the preform will expand during baking. The linear expansion is about 7 to 9% in the direction perpendicular to the applied pressure, and up to 25% in the direction of pressure. Some shrinkage occurs during the transfer of the part from the oven to the coining mold.

When preforming, sintering, and coining are done in the same mold, the shrinkage depends on the diameter of the piece. Table IV, p. 650, can be used as a guide for rods or tubes with wall thickness of ½ to 2½ inches.

In the case of tubes, the cores are made to the required nominal I.D.s.

Effects of fabrication

Properties such as stiffness, flexibility, tensile strength, and dielectric strength are affected by the process variables. Void content and crystallinity are two basic factors that affect the final properties of a molding (2). Since the voids which exist in the preform may be carried over into the finished article, the preform pressure is important. The rate of cooling is a key factor since it determines the final crystallinity of the molding. Table V, above, indicates the conditions necessary to obtain optimum values.

When considering a combination of properties necessary for a specific end use, it is important to note that the physical dimensions of a molded item may determine its final crystallinity by limiting the rate of cooling. Rapid cooling can be achieved for thin sections; however, in thicknesses greater than approximately ⅛ in., the cooling rate is limited by heat conductivity of the polymer.

The previously described techniques are basically applicable, whether the end product is a thin flat sheet, an irregular contoured seal, or a 60-lb. solid block. The molding method is usually dictated by end-product property and tolerance requirements, while the specific molding conditions are usually arrived at by making due allowance for the size and shape of the molded article. Detailed recommendations for fabricating specific items are available (3).

Stress relieving

Residual stresses are present in moldings which have been coined or rapidly cooled. In service, particularly at elevated temperatures, the stresses in these parts will tend to be relieved, resulting in distortion and dimensional changes. These can be kept to a minimum by stress relieving before use at temperatures above the maximum use temperature. On the other hand, molded pieces which have been free-cooled slowly are essentially stress relieved and no further treatment is necessary. As a rule, heat-treating for 1 hr./in. of thickness is adequate, provided that the molding is subsequently cooled slowly.

When extreme deformation during coining results in a high stress level, a molding will tend to revert to the original shape and dimensions of the preform at elevated temperatures. In such cases, service will be limited by the temperature at which the part distorts.

Safe handling practices

Animal feeding and other tests have indicated without exception TFE-fluorocarbon resins produce no harmful effect when taken internally and do not produce skin irritation. When TFE resins are heated in the range 400 to 600°F. (as in fabrication) minute quantities of gaseous decomposition products, some of which are unhealthy, are evolved. Generally, ventilation requirements will be of the same order as those for processing other plastics (4). No permanent injury known to be due to handling TFE-fluorocarbon resins has been reported to the Du Pont Company in the product's 20 year history.

Special references

1) "Effects of fabrication on the properties of Teflon resins," SPE J. (June 1956).

2) "Influence of process variables on shrinkage of moldings of Teflon polytetrafluoroethylene resins," SPE J. (Feb. 1957).

3) "Molding techniques of Teflon tetrafluoroethylene resins," Du Pont Information Bulletin No. X-7b.

4) "Safe Handling Practices," Du Pont Information Bulletin on "Teflon", X-59c.

For further information on tetrafluoroethylene, see p. 103; for data on extrusion of TFE resins, see p. 656.

In addition, consult the Subject Index and the Directory Index for additional information on the manufacture, processing, and sources of supply of tetrafluoroethylene (TFE) resins.

TRANSFER MOLDING: Rigid PVC

By R. J. Pecha*

It has long been recognized that rigid PVC has many properties which make it a desirable material for molded items, but the problem of thermal stability has hampered its development as a molding material. PVC resins and copolymers tend to decompose when subjected to the temperatures used in molding over the period of molding time required. Fig. 1 shows the time-temperature relationship for a typical PVC resin.

In the usual injection molding process, the theoretical time of residence of material in the heating zone may vary from perhaps 3 to 20 min., depending on shot size and cycle time. Some material, however, is likely to remain under heat for a much longer time because of nonuniform flow of material and non-ideal streamlining of injection cylinders. The result is that the injection molding stock temperatures which can be used for rigid PVC are limited to around 350° F. The material is so viscous at this temperature that high pressures are required to mold even the lower molecular weight resins; special costly equipment often has to be used; and pieces tend to be highly strained and to have poor strength at weld lines.

By applying high frequency preheating and plunger or transfer molding, it has been possible to mold rigid PVC successfully and to upgrade piece properties.

Using this process, rigid PVC may be heated into its critical temperature range, molded, and cooled through that range in from 60 to 120 seconds. This time interval is safely below the decomposition point (Fig. 1) for temperatures up to about 440° F.

Advantages of transfer molding include: 1) Compounds containing stabilizers and resins that are too unstable for use in injection machines can now be molded. 2) The higher permissible temperatures permit lower molding pressures. 3) More complex shapes can be molded. 4) Thinner sections can be molded. 5) Better weld strengths are obtained. 6) More uniform surface appearance and better gloss is obtained. 7) Higher molecular weight resins having more desirable properties can be molded. 8) Runaway decomposition, a danger always present in injection molding, is eliminated.

Molding procedures

After the desired compound is prepared and mixed homogeneously, it is high-frequency preheated. Halogen-bearing polymers exhibit a relatively high loss factor and may be heated at a reasonably rapid rate. Since PVC contains halogen, it will thus heat satisfactorily. An important consideration at this stage is the placement of the required shot weight in the preheater. The powder can be placed in glass Petri dishes, in a Teflon form set on Teflon coated glass cloth, or directly on the coated cloth. In the third case, the material should be leveled to a height of approximately ½ inch.

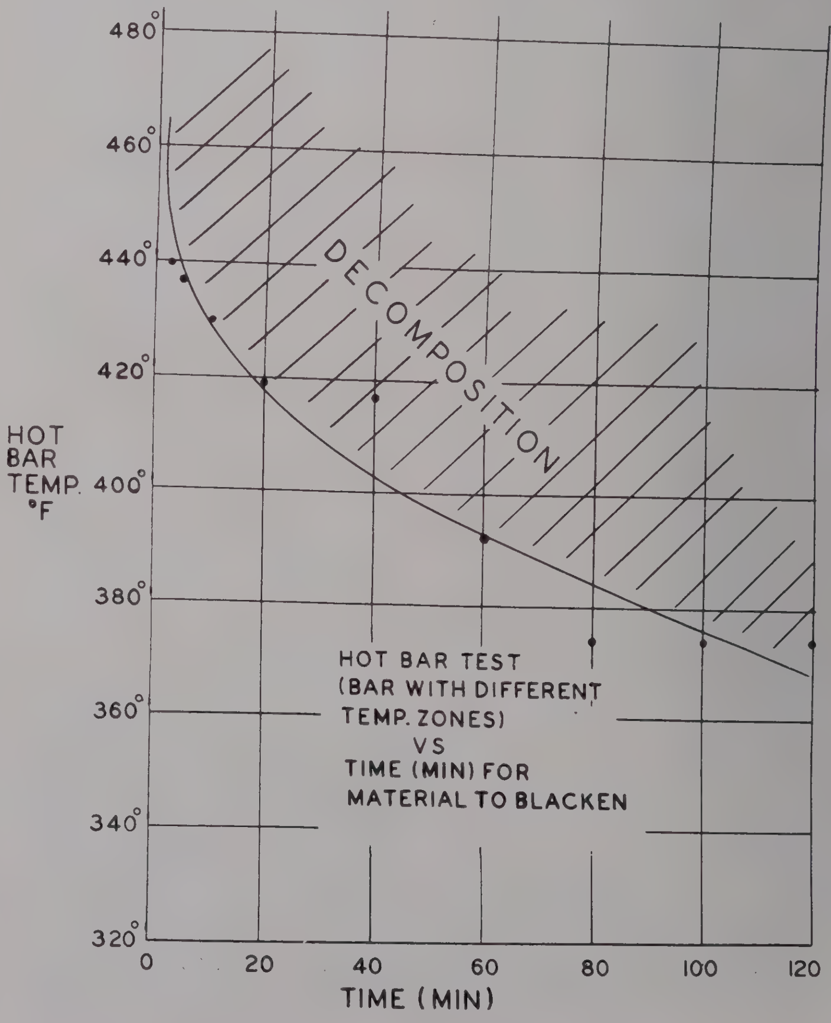
The preheater dial settings must be determined empirically because the values will vary with the type of equipment used. In all cases, the aim should be for a minimum preheat time.

As the powder is preheated to the specified temperature it becomes a semifluxed cohesive mass. It is then placed in the transfer-molding press, forced into a cold (room temperature) or warm (140° F.) mold, and allowed to set by cooling.

Athough molding experiments performed in the laboratory are limited to relatively small pieces, parts weighing as much as 3 lb. have been successfully molded in commercial field evaluations.

The problems of decomposition,

FIG. 1: Time and temperature vs decomposition of a typical PVC resin



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*Development Dept., Union Carbide Plastics Div. of Union Carbide Corp., Bound Brook, N.J.

splash marks, and sinks, common to the injection molding of vinyls, were greatly reduced in the plunger molding operation. The greatest over-all reduction of molding defects is achieved by the use of the maximum allowable stock temperature. Since the decomposition of PVC is time-temperature dependent, the time element must be kept small if higher temperatures are to be used.

Once the material has been heated to a high stock temperature, it cannot tolerate the addition of much heat during the molding process. Ideally, large gates and slow fill times should therefore be used to keep the generation of frictional heat to a minimum. Plunger pressure affects decomposition only when it influences fill time.

An additional reason for molding at maximum allowable stock temperatures is that weld strength increases with stock temperature. A flexural test bar gated at both ends and molded at 380° F., for example, had a weld strength of 5500 p.s.i. as compared to 7500 p.s.i. for a similar bar molded at 450° F.

Tests have demonstrated that the lower viscosity resins are easier to mold, give a slightly improved piece appearance, and can be molded over a wider range of stock temperature. Full round runners, a design feature commonly used in the injection molding of elastomeric vinyls, should be employed in the plunger mold. An open, unrestricted gate is also beneficial. Care should be taken, however, to see that the material is directed against a wall at a thin section in the piece. If the material is allowed to flow into a thick unobstructed area, jetting and splash marks may result.

Since the fastest possible preheat time and the highest possible stock temperature are desired, small changes in the preheat conditions can mean the difference between a good preheated shot and a decomposed shot. The grids should be parallel to insure uniform heating throughout the grid area. There should be no play in the grid height setting, and a voltage regulator should be used.

The plunger press should be equipped with a flow control valve so that fill time can be regulated independent of plunger pressure. With this device, slow fill time and high plunger pressures can be realized.

Consideration must also be given to proper ventilation. Toxic HCl gas and tin stabilizer fumes may be emitted from the preblend if it is overheated. The preheater should also be ventilated, since HCl gas will corrode the internal parts. If proper precautions are taken, no hazard exists.

Reground scrap can be utilized as a preblend constituent if it is ground finely (smaller than 10 mesh) and uniformly. However, when scrap is combined with preblend, certain temperature adjustments must be made. If only reground scrap is used, for example, stock temperatures must be lowered by at least 10° F. to prevent decomposition. For combinations of scrap and preblend, at least a 5° F. decrease is required.

Cost estimating for compression molding

By L. G. Spencer*

While cost estimating should always be recognized as one of the most important supports to the management of a sound business, today's extremely competitive atmosphere places added significance upon this function and demands a constant review of cost determination and cost estimating practices and procedures. This is especially true in the plastics industry, where the major business is strictly of a custom nature.

To establish a standard procedure for cost estimating in each cost element area, it is recommended that certain factors be considered.

Direct material: Under "direct material" costs come such items as molding compound, inserts, assembly parts, paints, etc. While the cost of these items is readily identifiable and accounted for, there are certain allowances which must be made to cover operating losses. By item, suggested accounting treatments follow:

1) On molding compounds, we must factor: a) net weight of molded part; b) minimum engineered flash; c) pill tolerance where compound is pelleted for compression molding; and d) operating waste.

The first item should be calculated as accurately as possible from the sample or print (or by weighing a prototype, if available), while the second represents the difference between gross and net weight as dictated by specific mold design. Here is where the engineer plays an important role in minimizing unit costs.

Pill-weight tolerance should be held to a bare minimum. However, it must be recognized that losses will occur in this area even under the best manufacturing conditions.

Operating waste representing floor losses (spillage), broken pills, burned pills, etc., must also be held to a minimum, but must be recognized as a definite operating cost.

Financial analysis will determine the degree of loss in each of the last two areas. With this knowledge, standard allowances can be established which should be applied to the "minimum gross weight" (items a and b).

Beyond the area of specific material costs, there are definite expenses incurred in connection with material planning, purchasing, expediting, handling, storing, etc., which should be isolated and allocated directly to molded part cost on the basis of pound usage. Too often, these material servicing costs are buried in general factory overhead with the result that unit costs of specific items are under- or over-stated. It should not be difficult to determine these material servicing costs, establish standard rates per 100 lb. of material, and reduce factory overhead accordingly.

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*Manager, Cost and General Accounting, Plastics Dept., General Electric Co., 2200 N. 22nd St., Decatur, Ill.

For cost estimating for injection molding, see Encyclopedia Issue for 1959, p. 30-33.

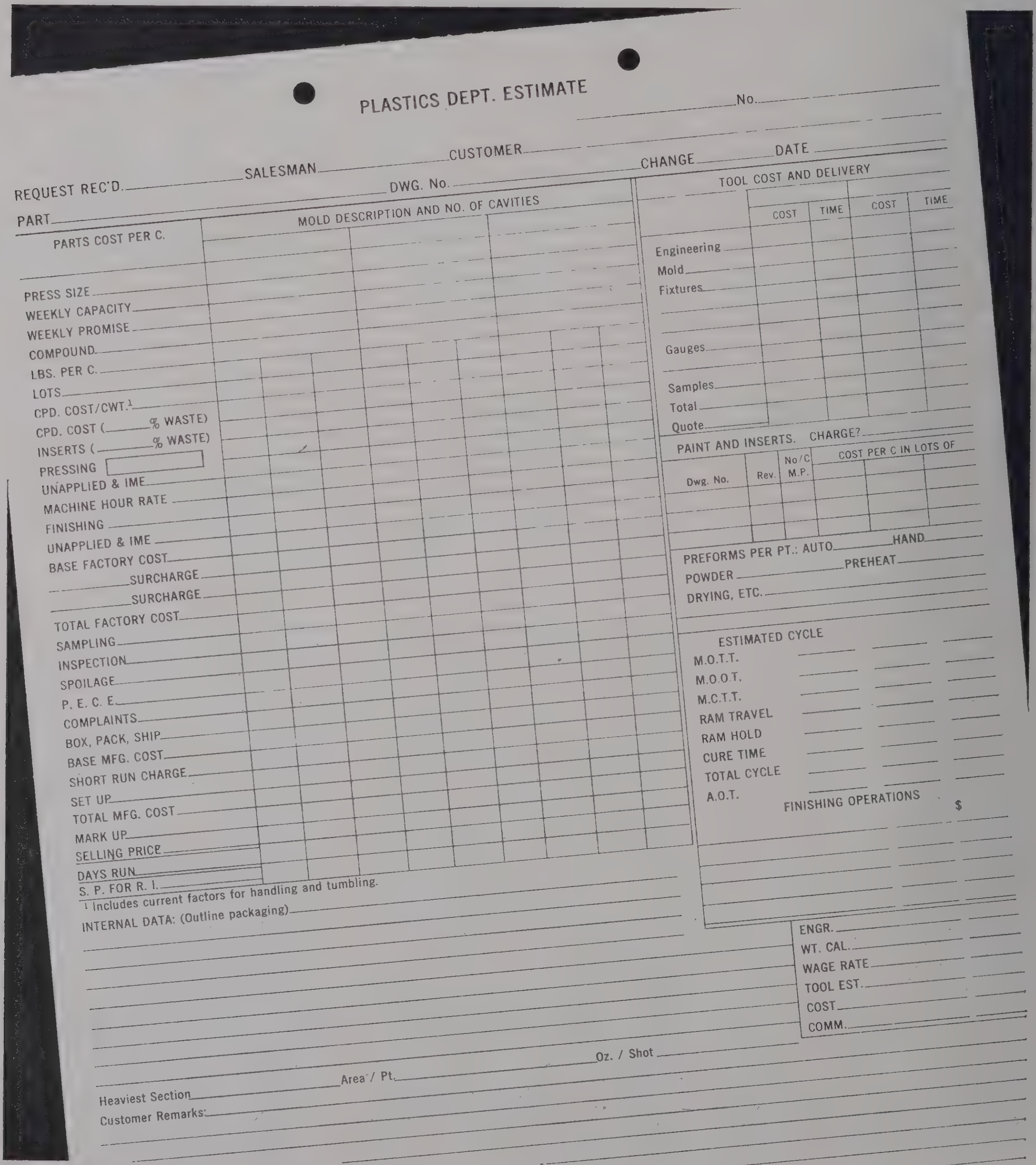
Pelleting costs should also be considered independently when determining or estimating unit product cost. Direct labor and factory overhead involved in pelleting should be removed from the total picture and allocated to unit product cost on a usage (poundage) basis. For accuracy of product cost, this cost should never be allocated on a common basis such as *% to direct labor* or *% to material cost.* Clerical expense can be reduced, and accuracy of unit cost improved, by combining material and pelleting costs into one composite unit figure.

With respect to inserts and assembly parts, standard allowances must be made for operating losses such as spillage, damage in handling, errors in ordering, etc.

Direct labor

While there is a lack of uniform treatment of direct labor within the industry, we believe

EXAMPLE of one of the cost estimating sheets used by the Plastics Dept. of General Electric Co.



PLASTICS DEPT. ESTIMATE

No.

REQUEST REC'D. SALESMAN CUSTOMER CHANGE DATE

PART DWG. No.

PARTS COST PER C.

MOLD DESCRIPTION AND NO. OF CAVITIES

PRESS SIZE
WEEKLY CAPACITY
WEEKLY PROMISE
COMPOUND
LBS. PER C.
LOTS
CPD. COST/CWT.[1]
CPD. COST (% WASTE)
INSERTS (% WASTE)
PRESSING
UNAPPLIED & IME
MACHINE HOUR RATE
FINISHING
UNAPPLIED & IME
BASE FACTORY COST
SURCHARGE
SURCHARGE
TOTAL FACTORY COST
SAMPLING
INSPECTION
SPOILAGE
P. E. C. E.
COMPLAINTS
BOX, PACK, SHIP
BASE MFG. COST
SHORT RUN CHARGE
SET UP
TOTAL MFG. COST
MARK UP
SELLING PRICE
DAYS RUN
S. P. FOR R. I.

[1] Includes current factors for handling and tumbling.

INTERNAL DATA: (Outline packaging)

TOOL COST AND DELIVERY

	COST	TIME	COST	TIME
Engineering				
Mold				
Fixtures				
Gauges				
Samples				
Total				
Quote				

PAINT AND INSERTS. CHARGE?

Dwg. No.	Rev.	No/C M.P.	COST PER C IN LOTS OF		

PREFORMS PER PT.: AUTO HAND
POWDER PREHEAT
DRYING, ETC.

ESTIMATED CYCLE
M.O.T.T.
M.O.O.T.
M.C.T.T.
RAM TRAVEL
RAM HOLD
CURE TIME
TOTAL CYCLE
A.O.T.

FINISHING OPERATIONS $

ENGR.
WT. CAL.
WAGE RATE
TOOL EST.
COST
COMM.

Oz. / Shot
Heaviest Section Area / Pt.
Customer Remarks:

that uniformity can be achieved by limiting direct labor to those operations performed directly upon the product and which add to the usefulness of it. Further, direct labor should be segregated between applied direct labor and unapplied direct labor. This segregation should be made in order to: 1) obtain a clearer picture of specific costs involved; and 2) bring about a sounder basis for current cost control.

Applied direct labor is that labor applied directly on the product as it moves through the normal process. Examples would be press, file, buff, assemble, paint, etc.

Unapplied direct labor differs from applied direct labor in that it represents items which, while necessary to further the physical progress of the part or product, actually reflect preparation, excess, or corrective labor. Respectively, such items would include setup and start-up, training, and rework labor. Some of these are necessary and some are not. However, under good manufacturing conditions, they will still exist to some extent. Accordingly, they should be provided for in product cost through the use of standard allowances added to applied direct labor.

Basically, all charges in the "unapplied" category represent payments to direct workers and are caused by the inefficiency of direct workers. It is therefore reasoned that such payments should be controlled as direct labor and the efficiency of these workers, as well as that of their foremen in planning their work, measured accordingly.

In cost estimating and in building unit product costs, the following standard procedure is recommended:

1) *Applied direct labor:* The estimated incentive payment, or daywork equivalent, applicable to specific operations.

2) *Unapplied direct labor:* This element should be allocated to unit cost by two specific avenues: a) The cost of the original setup should be charged against each customer requisition; and b) The cost of additional setups and all other "unapplied" items should be allocated to product cost on the basis of a standard allowance added to the applied direct labor content. This "standard" should be based on a factual financial analysis and should reflect only those costs applicable to normal operating conditions.

Factory overhead

Here, we are concerned with the largest single expense involved in converting raw material into the finished product. Other than direct labor, overhead embraces all plant conversion costs. Because of the nature and relative size of this specific expense, the basis of allocation to unit product cost is of vital importance as is the *accuracy of stated product cost.* In this connection, there has been no uniform practice followed by the plastics industry in allocating factory overhead to unit product cost.

In reviewing factory overhead, it should first be purified of any specific expense which is a "natural" for liquidation on a more logical basis than labor or machine hours. One of these is the cost of servicing material. Another, it is believed, should be quality control costs.

After eliminating specific items of expense which it has been reasoned should require independent allocation, the next step should be to isolate those expenses which are incurred directly by labor, or which vary generally in proportion to direct labor. Some of these would be: 1) certain types of supervision; 2) night workers' bonus; 3) a proportionate share of dispensary costs; 4) vacation and holiday pay; 5) some insurance expense; 6) general employee benefits; 7) certain supplies: etc. These expenses can be readily determined and agreed upon by supervision. They should be allocated to unit product cost on the basis of a standard factor applied to the direct labor content.

After eliminating those expenses outlined in the preceding two paragraphs, the factory overhead remaining should be that which is related to equipment usage or time. Expenses in this category are depreciation, taxes, insurance, rentals, electric energy, steam production, maintenance, planning and methods, certain supplies and tools, certain supervision, etc. These expenses should be liquidated in unit product costs on the basis of a standard machine hour rate. Rates will vary, of course, according to specific machine size.

In analyzing factory overhead expenses applicable to *time,* those expenses applicable to electronic preheaters should be segregated and liquidated on a machine hour basis on those items which actually employ preheaters.

The total of direct material, direct labor, and factory overhead is called factory cost. It represents the true base of factory production. It is the base against which some of the subsequent elements of cost should be allocated as well as the cost level at which inventories should be carried.

Manufacturing cost

Spoilage losses are allocated to unit product cost on the basis of a standard allowance related to the factory cost of specific molded parts. On items having inherently high losses, a higher than normal rate should be used.

Engineering expense may be broken down into three major categories. These would be: design; product; and process.

Design expense should be allocated to the cost of new molds. Process engineering concerns itself with the regulation and improvement of the manufacturing process. This expense, then, should be included in the factory overhead. Product engineering expense should be related to plant output and allocated to unit product cost. Also, the unit product costs should include packing expense on a basis as near actual as possible. However, a standard ratio applied to the factory cost of specific molded parts will be found to be satisfactory in a majority of the cases.

It is suggested that allowance in cost for customer returns be on a basis of a standard factor applied to unit factory costs.

Each of the elements of manufacturing cost described above represents the total area for which manufacturing is responsible. This cost is generally used as a guide in establishing unit selling prices.

Extrusion

IN THIS SECTION

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Wire jacketing nylon 677
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In plastics extrusion, the compound, in granular or powder form, is reduced ("plasticated") to a more or less viscous liquid by a combination of direct heating and shearing action. It is then forced out through an orifice or "die" from which it emerges as a sheet, rod, tube, wire coating, or any other profile as dictated by the die shape. The extruded shape, known as the "extrudate," is then cooled and transported by take-off equipment to cutters, slicers, or wind-up rolls, depending on the desired end product.

Most plastics extrusion subjects the compound to heat and shearing in a cylinder within which revolves a closely fitting screw that moves the material from a feed hopper to the die. The exception is in ram extrusion, used with TFE resin, as described on p. 667. In this process, a ram rather than a screw, moves the material.

EXTRUSION: Acetal resin

By Paul N. Richardson[*]

Two grades of Delrin[1] resin are offered for extrusion: a high-viscosity general purpose extrusion grade (150), used for most extrusion operations, and a low-viscosity special purpose material (550) for use with dies with very small openings such as certain wire-coating dies. The processing properties of both resins are the same except for melt viscosity.

Volume change

Acetal resin undergoes a relatively large volume change when cooling from the melted state; the volume changes of acetal resin and high-density polyethylene are very similar and they are both larger than the changes for low-density polyethylene and nylon. As a consequence, careful control of the cooling of acetal is required to prevent distortion of the extrudate. The type of control which is required depends upon the rate at which the resin is permitted to freeze.

Acetal resin sets up very rapidly. Only the 6/6 nylon resins freeze faster. In contrast, low-density polyethylenes set up much more slowly. Rapid freezing means that quenching is not a problem, but it also means that the cooling of the outside skin of an extrudate must be done very carefully to avoid surface blemishes and dimensional distortion. If water is used as the initial quenching medium, the surface of the water must be carefully controlled. Cooling against a polished metal surface, such as the rolls of a three roll finisher used for sheet extrusion, gives excellent control.

The use of a hot quench medium will slow down the freezing rate somewhat and may provide for easier control of the take-off process. A hot quench also tends to make the extrudate have a glossier surface.

Thermal stability

Acetal resin, like all polymers, will degrade if it is heated for too long a period of time or at too high a temperature. Recommended processing conditions (Table I, p. 657) are well within the stability limits of the resin, and there is a margin of safety if abnormalities of processing conditions are encountered. However, care should be taken not to process the polymer above recommended temperatures or to allow a hot machine full of resin to stand idle.

Perhaps the best evidence concerning thermal stability of the resin is that rework can be handled without difficulty. The resin has been reprocessed through an extruder several times without a noticeable change in stability or change in color. Furthermore, extruder dies which are full of resin have been shut down and reheated without causing the resin in the extruder to degrade. However, it is a better practice for the extruder screw to be pumped dry before a shut-down.

In contrast to a number of other resins, neither the stability nor the color of acetal resin is affected by the presence of air during normal processing. This is true even though the acetal resin is melted or is being worked in an extruder.

Materials which are acidic or basic can cause degradation of the resin, and it is therefore important to consider this when selecting pigments or other additives. Although there are a few pigments which are unsatisfactory for this reason, there are a great number of pigments which do an excellent job of coloring acetal resin without causing degradation.

Extrusion equipment

Acetal resin has been successfully processed in many extruders of different designs and sizes. No special design considerations are necessary, and no special materials of construction are required. However, copper or brass should not be used in the construction of hot die parts as they promote degradation. The following design considerations of commercial equipment are important in getting optimum results in extrusion of acetal.

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[*] Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.
[1] Trademark of Du Pont.

Extruder barrel: Barrels with high ratios of length to diameter (20:1 or greater) are advantageous because they increase the available heat-transfer area in the machine and they provide for a greater uniformity of output and melt temperature.

Either electrical heating or oil heating may be used on barrels of extruders for processing acetal resins. Electrical heat is preferred, because of its simpler installation and greater versatility. The barrel should be heated in several independently controlled heating zones.

Extruder screw: A metering type constant-pitch screw is suggested for the extrusion of acetal resin, with dimensions as given in Table II, p. 658. Screws with deeper channels are likely to give unmelted particles in the melt at high screw speeds; shallower screws at high screw speeds may overwork the melt and produce a melt temperature higher than is desirable.

Breaker plate and screens: When using metering type screws, screen packs usually are not used when processing the high-viscosity resin. However, a screen pack consisting of two or three 80 or 100 mesh screens is used when processing the low-viscosity resin. A breaker plate is always part of the setup.

Dies: Acetal resin can readily be extruded through standard dies, which should be carefully streamlined. Sharp corners, unnecessary seams, joints, and dead pockets should be eliminated. All die assemblies must be carefully tightened to prevent penetration of the resin into cracks and openings. Dies built without the necessary care can cause localized decomposition of resin in dead spots where the resin doesn't move.

Heater bands on the die bodies should be located in such a way that heat can be applied evenly to all portions, without localized overheating. It may be desirable to insulate the die in order to keep temperature differences in the die body at a minimum.

TABLE I: Extrusion of acetal resin

A) *Machine characteristics*	*Tubing*	*Sheeting*	*Wire coating*
Diameter, in., of screw needed to deliver at 60 r.p.m.:			
50 lb./hr.	2	2	2
150 lb./hr.	3¼	3¼	3¼
Recommended L/D	20:1	20:1	20:1
Recommended screw type		Metering	
Compression ratio[1]	3:1	3:1	3:1
Depth of feed zone in 150 lb./hr. screw, in.	0.470	0.470	0.470
Lead ratio[2]	1:1	1:1	1:1
Screen pack	None	None	None
Drive power for 150 lb./hr., hp.	20-30	20-30	20-30
B) *Operating conditions*			
Melt temperature at die, °F.	390-410	390-410	390-410
Aprox. melt pressure at die, p.s.i.	1000-2000	500-1500	1500-8000
Screw cooling	No	No	No
Feed preheating	No	No	No
Metal temperatures, °F.			
Rear cylinder	400	400	400
Halfway along cylinder	400	400	400
Forward cylinder	400	400	400
Die	400	400	400
Is extrudate water quenched?	Yes	No	Yes
Water temp., °F.	70	—	70
Air gap, in.	1-3 in.	—	4-8 in.
Time in water, sec.	3	—	1
Draw ratio[3]	4:1 to 8:1		2:1 to 40:1

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[1] $\text{Compression ratio} = \frac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[2] $\text{Lead ratio} = \frac{\text{Distance between corresponding points on successive turns of same flight}}{\text{Inside diameter of barrel}}$

[3] $\text{Draw ratio} = \frac{\text{Cross-sectional area of die opening}}{\text{Cross-sectional area of finished (untrimmed) extrudate}}$

Extruder operation

Start-up procedure: A clean extruder should be heated to 350° F. and allowed to soak for about 30 minutes. Then the barrel should be brought up to the operating temperature of 380 to 420° F., with overheating avoided. Generally, the die and barrel are heated to the same temperature over the entire length.

If the extruder contains another resin, it should be purged with a polyethylene resin of melt index 1.8 or higher. The barrel temperature should then be adjusted to approximately 400° F., and the polyethylene purged with the acetal resin. No further adjustment of temperature should be required. Under no circumstances should acetal resin be processed above 450° F.

Temporary shut down: In any

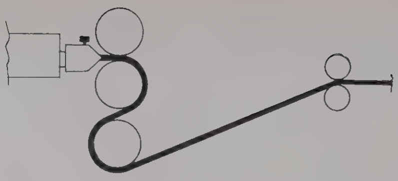
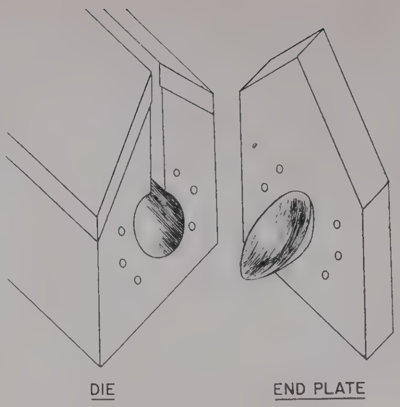


FIG. 1: Three-roll finishing set-up for preparing extruded acetal sheeting. **FIG. 2 (RIGHT):** Sheeting die and end plate, showing streamlining to avoid pockets where resin might stagnate and decompose



prolonged shut down of extrusion equipment, care should be taken to avoid exposure of resin in the machine to high temperatures for longer periods than necessary. If the machine is to be kept hot during the shut down, it is advisable to continue extrusion at a very slow rate, bleeding off the extrudate. If this is not desirable, the machine should be run empty, and temperatures reduced below the melting point of the resin.

Permanent shut down: If the machine is to be shut down and to be run with acetal resin again, the screw should be run dry and the barrel and die heats turned off. If the machine is to be shut down and is not to be run with the resin again, the screw should be run dry and the die and screw removed from the extruder before the resin sets up. As the parts cool, the polymer will shrink and crack away from the metal, and can be chipped off easily. An alternate method is to remove the resin in a burn-out furnace.

Small die parts may also be cleaned by burning with a hand torch. The flame of the burning acetal resin has a faint blue color, produces no smoke, and is somewhat difficult to see.

If it is not possible to clean the die and extruder before processing another resin, it is suggested that the acetal resin be purged from the extruder with a polyethylene resin of melt index 1.8 or higher at the same conditions that were used with the acetal resin.

Moisture considerations: The virgin resin can be processed directly as it is received. It is not necessary to dry this material prior to extrusion; but since the resin is slightly hygroscopic, precautions should be taken to minimize exposure to moist air prior to extrusion. The equilibrium moisture content of acetal resin at 70° F. and 50% R.H. is 0.2%. For best extrusion results, the moisture content should not exceed 0.25 per cent. The resin should be stored in the unopened shipping container which, after opening for removal of material, should be closed tightly. Hoppers of extruders should be kept covered.

Use of rework resin: Polymer which is to be re-used immediately will usually not require drying. Rework which has been allowed to accumulate for some time may require drying depending on its moisture history. A drying cycle of 3 to 4 hr. in a circulating air oven at 175° F. is usually sufficient to reduce the moisture content to an acceptable level.

Typical extrusion processes

Sheet extrusion: A three roll finisher (Fig. 1, above) may be used in conventional manner to prepare sheeting extruded from acetal resin. The extruder die feeds melt directly into the nip of the rolls; pull rolls maintain tension on the sheeting and pull it away at a constant rate. The linear take-off rate should be at least 18 in./min. in order to prevent excessive droop of the extruded sheet.

The sheeting die should deliver a web of melt of even caliper to the nip of the rolls, with provision for easy adjustment of caliper. The die opening should usually be 10 mils larger than the sheet thickness, and should incorporate extended jaws, so that the length of the air gap can be minimized. For heavy sheeting (greater than 65 mils), the die should be provided with a restriction (dam) in the flow path to help even out the flow of the resin. The die end plates should be streamlined (Fig. 2, above) to avoid degradation of the resin in the ends of the manifold.

Purpose of the three roll finisher is to cool the resin and to provide a glossy surface to the sheet—not to iron out imperfections of caliper, which is a function of die adjustment. The sheeting reproduces the surface of the rolls, and any imperfections on their surfaces show up as defects in the sheeting. The best surface is obtained with hot rolls, optimum roll temperature depending upon the linear take-off rate and to some extent, upon the thickness of the sheet. It will fall in the range of 200 to 300° F. The rolls are commonly pressured with compressed air,

TABLE II: Dimensions of screws for extrusion of acetal resin

Diameter (D)[1]	*Pitch (P)*	*Width of land (w)*	*Depth of feed section (h_1)*	*Depth of metering section (h_2)*
in.	*in.*	*in.*	*in.*	*in.*
1½	1½	0.150	0.240	0.075
2	2	0.200	0.320	0.090
2½	2½	0.250	0.390	0.105
3¼	3¼	0.325	0.470	0.125
3½	3½	0.350	0.475	0.130
4½	4½	0.450	0.550	0.150

---

[1] Key letters correspond to those on extrusion screw drawing on p. 679.

and a pressure of 60 to 100 p.s.i./in. of length of the rolls has been found satisfactory. Excessive pressure results in build up of a bank of excessive resin at the nip of the rolls, and can cause imperfections in the sheet.

Tubing extrusion: Free extrusion of tubing is a common process for many thermoplastic resins, and no special equipment is needed for handling acetal resin. Horizontal extrusion is preferred, especially for tubing of fairly large diameter. Either a straight through or a cross-head tubing die can be used, with the former preferred because of the small hold-up volume of the die. The spider which supports the male part in a straight-through die will not cause a weld line problem with acetal resin if it is streamlined with respect to the flow of the resin. If a cross-head die is used, a restriction or choke in the die (Fig. 3, above) is helpful in facilitating equal flow of resin around the die.

For horizontal extrusion, a quench tank 6 to 10 ft. in length will be satisfactory. For experimental runs or low production rates, an even shorter quench tank can be used. The tank is located approximately one to three inches from the die opening, and in the air gap, draw down of the tube takes place. Draw down ratios from 4:1 to 8:1 may be used. The tube is prevented from collapsing by a very low internal pressure (1 to 6 in. of water head) of air. To insure tube roundness, the water level in the tank should be held constant in the range of ¼ to ¾ in. above the tube.

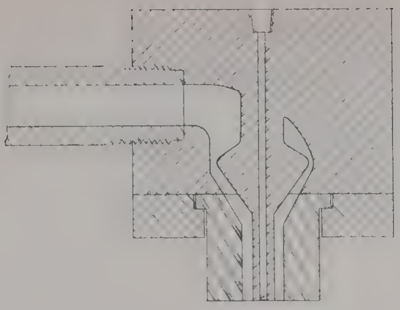


FIG. 3: Cross-head die for acetal extrusion has built-in choke

A pull roll type of constant speed take-off is very satisfactory for small diameter tubing extrusion. Rubber covered rolls should be used which give a tight grip and prevent slippage. Grooved or contoured rolls will prevent distortion of the tube. The unit should be capable of speed adjustment up to a linear take-off rate of approximately 200 ft./min.

Wire coating: The low-viscosity grade of acetal resin is used for wire coating. Under the proper conditions, the polymer can be applied to the wire in thin coatings and at high rates. Standard wire coating equipment may be used. In the coating operation, cold water is used in the quench bath, and the bath is so located as to allow a 4 to 8-in. air gap between the die and the water. Draw downs of 2.5 to 1 to 40 to 1 have been used. High draw-downs are required for thin coatings and a low vacuum (1 to 2 in. of mercury) is needed to pull the resin onto the wire. For heavy coatings, no vacuum is required. Thin coatings (5 to 10 mils) have been applied to wires at rates up to 1800 ft./minute.

EXTRUSION: Acrylics

By J. F. Garber*

The acrylic molding powders used for extrusion correspond to Grades 6 and 8 (A.S.T.M. D-788-56 T). These materials vary primarily in softness, the harder molding powder (Grade 8) having better heat resistance and permitting a higher maximum service temperature.

High impact acrylics (Implex[1]) have recently come into general use, and extrusion of this polymer will be discussed later in the article.

The acrylics have excellent flow characteristics. The surfaces of extruded material have good gloss. The thermal stability of these polymers makes it possible to extrude them without serious difficulty due to degradation. Storage and handling problems are the same as those which are encountered with acrylic injection molding powders (see p. 597).

Type of equipment

Conventional single-stage extrusion machines and vented (two-stage) extruders are used for extrusion of acrylics. A single-stage machine should have at least two separately controlled heating zones along the cylinder, plus separate controls at the die and a water-jacketed section at the feed-hopper zone. Variable-speed drive should be provided for the extruder. For most acrylic extrusions, the single-flight, constant-pitch, continuously-increasing-root-diameter screw, without a torpedo (full-flighted), is satisfactory (see Fig. 1, p. 660). Torpedoes have been used to advantage in some applications, although they may tend to increase melt temperature.

Drying

When preparing acrylic polymer for extrusion on single-stage machines, the feed must be very thoroughly dried. For a discussion of drying procedures, see the article on injection molding of acrylics, p. 594. With vented extruders, predrying may not be necessary.

Die design

The heat stability of the acrylics allows them to be used in dies where the flow path would cause serious color degradation in less stable materials. In order to produce the highest possible surface gloss, it is necessary that the die lands be given a good smooth finish extending at least ¾ in. back from the emerging face.

As is the case for all rigid thermoplastics, a constant die temperature is necessary, particularly where close dimensional accuracy is required in the finished product. Electric heating is relatively simple and can be controlled satisfactorily, using reasonably inexpensive equipment. As the width or complexity of the extruded part increases, the need for close temperature control becomes increasingly important.

Adequate insulation is a neces-

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* Research Engineer, Plastics Laboratory, Rohm & Haas Co., Bristol, Pa.

[1] Trademark of Rohm & Haas Co.

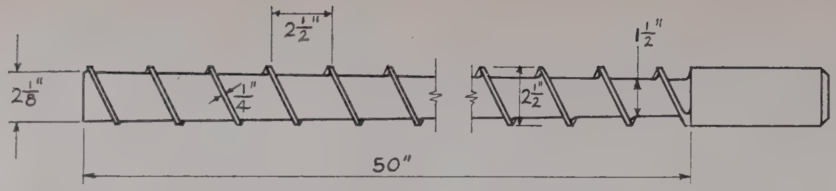

FIG. 1: Typical dimensions for a 2½-in. extrusion screw for acrylics

sary adjunct to accurate die temperature control if dimensional accuracy is to be maintained. Without proper insulation, minor drafts and air currents may seriously affect the die temperature, resulting in variations of product dimensions.

Preferably, dies should be designed to provide the necessary back pressure for stable operation of the screw without the use of screen packs. This can often be accomplished by the use of long lands or restrictions behind the lands.

Sheeting die

A typical center-fed die suitable for the extrusion of 48-in.-wide acrylic sheeting is shown in Fig. 2, p. 661. Uniformity of sheet thickness can be varied by adjusting the temperature zones across the width of the die or by adjusting the opening "T" across the die.

TABLE I: Extrusion of acrylics

A) *Machine characteristics*	*Sheets and shapes*	*Rods*
Normal output, lb./hr. from screws (L/D=20) of:		
2½ in. dia.	60	50
3½ in. dia.	160	140
4½ in. dia.	250	—
Recommended screw type	Full-flight, constant pitch, variable-depth	
Compression ratio[1]	2:1	2:1
Minimum flight depth, in.[2]	3/16	¼
Lead ratio[3]	1:1	1:1
Screen pack	Preferably none	Preferably none
Drive power, hp./(lb./hr.)	1/10	1/10
B) *Operating conditions*		
Melt temp. at die, °F.		
General-purpose, A.S.T.M. Type 6	360-400	340-380
Heat-resistant, A.S.T.M. Type 8	380-420	350-400
Melt pressure at die, p.s.i.	400-1800	100-500
Screw cooling	Not recommended	Not recommended
Entering temp., °F. (Must be constant)	Up to 200	Up to 200
Metal temp., °F.		
General-purpose type		
Rear cylinder	340-440	340-390
Center of cylinder	340-390	340-390
Front of cylinder	310-360	310-340
Die	360-400	340-380
Heat-resistant type		
Rear cylinder	350-450	350-400
Center of cylinder	350-400	350-400
Front of cylinder	325-375	325-350
Die	380-420	350-400
Feed throat temp., °F.	125-180	125-180
Maximum draw ratio[4]	1.15	—

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[1] Compression ratio $= \frac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[2] Dimensions for 2½ in. screw; add 1/16 in. for each 1 in. increment of screw diameter.

[3] Lead ratio $= \frac{\text{Distance between corresponding points on successive turns of same flight}}{\text{Inside diameter of barrel}}$

[4] Draw ratio $= \frac{\text{Cross-sectional area of die opening}}{\text{Cross-sectional area of finished (untrimmed) extrudate}}$

In practice, it is preferable to use a combination of the two adjustments. For optimum thickness control of the extruded sheet, the temperature gradients should be established so that the lip opening "T" can be as nearly uniform as possible and approximately equal to the desired sheet thickness.

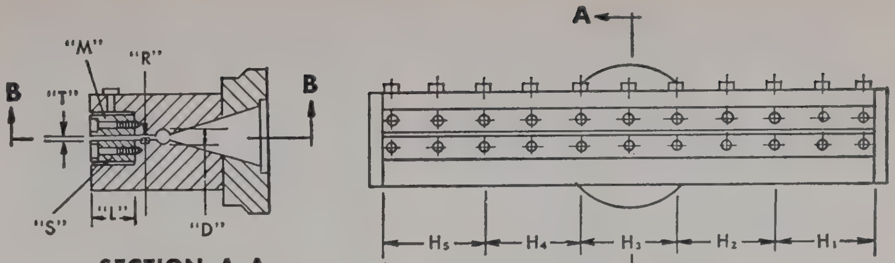
In Fig. 2, "R" represents a restriction placed in the material path to supply a reasonable resistance to material flow in addition to that supplied by the extrusion die opening. The need for this restriction increases as the opening of the lips increases; hence, the restriction "R" may be considered as a substitute for a longer land on the forming lips ("M" and "S"). "D" represents a distributing channel to convey the material across the width of the die. The dimensions of this channel must be large enough to reasonably limit the pressure drop from the center of the die to the ends. The dimensions "R," "D," and "L" should be determined with some consideration of the extruder and screw with which the die will be used.

Oversize dies

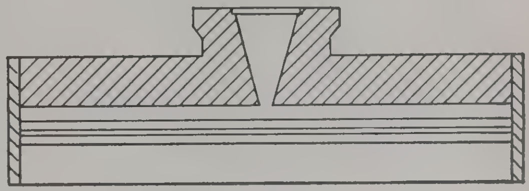
In most operations, it is necessary to use dies somewhat oversize and draw the material to retain shape after it emerges from the die. This drawing will cause some degree of elastic stresses to be frozen into the sheet. The amount of these stresses will be directly proportional to the amount of drawing and inversely related to the polymer temperature at which the drawing occurs. Since such stresses weaken the extrudate and cause warpage and shrinkage if the material is reheated to its softening temperature, the amount of drawing should be minimized. A figure of 15% maximum offers a reasonable working figure.

Start-up

Barrel temperatures and screw speed vary according to the screw type and restrictions imposed by the die. Equipment should be started at somewhat higher than



SECTION A-A



SECTION B-B

FIG. 2: Center fed die, divided into 5 separately controlled temperature zones, is suitable for 48-in. wide acrylic sheeting. Section views show features of the polymer flow path

recommended operating temperature. After actual extrusion starts, temperatures should be worked down to the ranges indicated in Table 1, p. 660. Precise operating temperatures will be dictated by the conditions of extrusion. Low ranges of screw speed should accompany the high initial start-up temperatures.

Take-off

Since acrylic extrusions have a high surface gloss as they emerge from the die, polishing rolls are not necessary on the sheet take-off.

Take-off equipment should be designed to preserve the luster of the extruded surface by using minimum contact area consistent with retention of the shape of the extruded form.

Air cooling is usually employed at take-off. It should be applied uniformly over the surfaces, and the material should be shielded from stray drafts. Care should be taken to avoid chilling the die itself. Cooling rates should be slow to avoid hardening the surface while the internal material is still at a higher temperature, particularly when extruding heavy sections. If proper care is not exercised, bubbles may result from thermal contraction of the material (internal shrinkage) after surface hardening.

Short water quenches can be employed but may cause internal-shrinkage bubbles.

Purging

Where a quality product (free of contamination) is expected, particularly in clear or transparent acrylic, the extruder screw should be removed and the screw and barrel thoroughly cleaned. Color changes in one flow grade are frequently made by simple purging, particularly when changing from a clear or light transparent color to a darker and more opaque color. The elimination of potential contaminants from the previous material can usually be hastened by stopping the extruder several times for a 10 to 20 min. "heat soaking" of the equipment before restarting.

The same comments apply when shifting from Grade 8 to Grade 6 (or vice versa), in which case the extrudate will show an "optical distortion" during the purging changeover and a continuously decreasing appearance of "gel-like" surface irregularities.

In cases where a screw is to be removed for cleaning after running acrylic powder, the majority of the polymer may be removed from the screw by first feeding granulated acrylic cast-sheet scrap to the machine. If this procedure is used, the die should be first removed and the head opened to remove breaker plate and screens. It is *not* recommended that cast-sheet scrap be used to purge screws with long torpedo elements. Granulated cast-sheet scrap will not melt down to a viscous fluid, but will pass along the screw as softened, rubber-like particles which will remove the majority of molten polymer from the screw.

If the screw is to be removed, the addition of a few ounces of dioctyl phthalate (DOP) or tricresyl phosphate (TCP) through the feed hopper will soften the polymer to permit easy removal. (The extruder should be cooled to 300 to 350° F. before the plasticizer is added.) The barrel may then be cleaned by running through a rag dampened in DOP or TCP, followed by a dry rag to remove the solvent.

High-impact acrylics

The following information on extrusion of high-impact (Implex) acrylics supplements the section immediately preceding, which should be consulted to obtain a balanced survey of acrylic extrusion.

Type of equipment

For most applications, full-flighted screws with a constant pitch and decreasing channel depth are preferred. Channel depth at the delivery end of the screw should be in the range of ¼ in. for a 2½ in. diameter screw to 5/16 in. for a 4½ in. diameter screw. Compression ratios should be in the range of 2:1. The conventional shallow-channel (less than ⅛ in.) metering type screws are not desirable. Screws with long mixing torpedoes or conventional smooth torpedoes with limited clearance should also be avoided.

Drying

Implex A can be dried at temperatures up to about 210° F. Since prolonged drying at elevated temperatures in contact with air gradually produces a discoloration of the material, high-impact acrylics should not be dried longer than 16 hours. Vented extruders seldom require predrying.

Extrusion conditions

High-impact acrylics can be extruded as sheet, tubing, and contoured shapes. Actual operating conditions are usually dependent on screw design, rate of operation (throughput), and flow requirements of the die. Barrel temperatures of 425° F. on the rear half and 400° F. on the front half are good starting points. Preferred conditions can be established as indicated by trials. The usual experience with the preferred screw types is that lower front barrel temperatures are desirable. With shallow-channel screws, shifts in this direction usually do not reduce material temperatures due to the large amount of work being done on the polymer.

Dies are usually operated in the range of 360 to 420° F. Dies operated at the upper end of the range, or at still higher temperatures, will show a gradual accumulation of polymer around the die opening which is objectionable on an extended run. The presence of moisture aggravates this condition, while lowering the die temperature reduces it. Increased die temperatures usually produce improved gloss.

Take-off

As the material is extruded from the die it is semiliquid and must be stretched or drawn to hold its form as it is conveyed away from the die. The drawing operation tends to orient the polymer, but this is usually not objectionable. However, drawing should be kept at a minimum for optimum properties—particularly dimensional stability—for subsequent forming operations.

The extruded material is quite soft as it emerges from the die and requires support while it is cooling. This is usually accomplished by use of water- or air-cooled fixtures which support the material until it cools sufficiently to be handled on a conveyor or other drawing mechanism.

Applications: The high-impact acrylics are being extruded and formed for such applications as motor housings on motor boats, where the toughness and chemical resistance of the material may be used to particular advantage. Most of the other properties of the acrylic family—such as resistance to staining, lack of unpleasant odor or taste, high surface gloss, dimensional stability, and stiffness—are also characteristic of high-impact acrylics.

EXTRUSION: Cellulosics

By A. Bonwit*

Extrusion methods for the cellulosic resin family differ from the other thermoplastics in small but significant ways. This family includes cellulose acetate, cellulose acetate butyrate, propionate, and ethyl cellulose. While some variations are observed between the individual members, the following guide is broad enough to adequately cover all cellulosics.

Table I, p. 663, summarizes machine characteristics and operating conditions for extrusion of these materials; supplementary information is given in the following paragraphs.

Extrusion equipment

L/D ratio: Minimum L/D screw ratio is 15:1. 20:1 is preferred for nonvented extruders, and 24:1 for vented extruders.

Screw design for nonvented extruders: Full-flighted constant pitch with metering tip and a 4:1 compression ratio. Compression section should be ½ turn.

Screw design for vented extruders: Full-flighted with metering section before the vent, decompression section at the vent, and another metering section at the discharge end. Since this type is actually two screws on a single axis, design is critical. The pumping capacity of the two screws must be balanced to prevent resin from rising in the vent. However, the balance should not be so far in the other direction as to cause starving of the front section, which results in surging.

Screw water: In most cases, no water is required in screws of the above designs.

Extruder heating: Electric band heaters should be used in zones, the number dependent on machine size.

Instrumentation: On-off temperature controllers may be used provided the cycle time is no greater than 15 seconds. It is desirable to check controller periodically and for this a dual thermocouple is well suited. A melt thermocouple and pressure sensor are desirable in the gate on critical applications.

Drying: Hopper driers or tray driers are used on nonvented extruders. Drying time is usually about 1½ hours. The feed to the extruder must not contain moisture above 0.1 percent. The drying temperature range is between 125 and 210° F., depending on the compound.

Vented extruders should be equipped with a vacuum source to remove the moisture and volatiles.

Screen packs: Screen packs serve to filter out contaminants introduced with or in the molding power. With the recommended screw designs, screens are not usually necessary for any other extruder need. Therefore, screen size is based primarily on quality requirements of the end product.

Use of screens is strictly a balance of quality and economic factors. Screens require occasional changing which incurs costs but also improves quality somewhat. Each end use has its own balance in this regard.

Breaker plate design: The breaker plate which retains the screens in place should be made with tapered holes (counter to direction of flow) and countersunk at both ends about ⅛ to ¼ in. in diameter. The taper eases removal of solidified resin. The breaker plates should have a smooth finish on all surfaces.

Gate design: The gate opening should quickly taper down to less than ¼ of the extruder barrel diameter. This assures rapidly moving resin without large temperature gradients.

The sealing surfaces of the gate, breaker plate, extruder, and die should be kept in good repair. Leaks at these places can lead to flow lines, voids, and thickness variations in the extrudate.

The gate may incorporate quick opening features where screen and color changes are frequent.

Die design

Care should be taken in design to streamline the flow path and also eliminate any possible areas of stagnation which would eventually result in thermal degradation at melt temperatures. (See Fig. 1, right.)

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*Senior process engineer, Plastics Div., Celanese Corp. of America, 290 Ferry St., Newark, N. J.

Constructional details for shapes and forms cannot be outlined here as they represent individualized problems. In general, however, highly polished surfaces and long lands consistent with machine throughput give best finish and dimensional stability. Chrome plating is recommended for higher gloss and smoother flow.

Manifold type dies are generally used for sheeting. Choke bars can be used, but, again, care is needed to avoid stagnation points.

Instrumentation of the zone heated die is much more critical with cellulosics than for many other thermoplastics. Small temperature variations between zones can lead to considerable variation in thickness. Control should be maintained at about ±2° F.

Take-off equipment: As the hot melt emerges from the die, some size reduction due to draw-down is inevitable. It is desirable to cool the extrudate quickly and support it uniformly, since cellulosics can "freeze-in" stresses by stretching after partial cooling. This is important in heavier sections which are reheated and reformed after extrusion and where long-term warpage creates problems. Uniformity in take-off speed is essential for high-precision products.

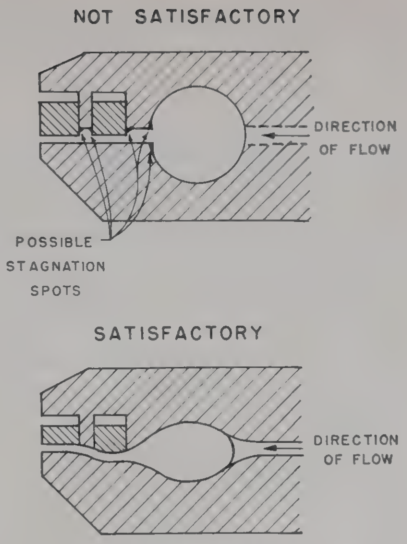

FIG. 1: Satisfactory extrusion die for cellulosics presents a smooth, unobstructed flow path for material being processed

Cooling

Cooling troughs are used in the manufacture of tubing, pipe, rod, shapes, and forms. The cooling media are air, temperature controlled water, and cold water; the choice depends on the product being produced. For example, for small diameter tubing produced at a high rate, air and cold water are used. For large diameter pipes, room temperature air at about 100 to 130 c.f.m. is used with supports. Shapes and forms require special consideration since their irregular cross-sections must be cooled at equal rates in order to avoid any possibility of warpage.

TABLE I: Extrusion of cellulosics

A) *Machine characteristics*

Diameter, in., of screw needed to deliver at 60 r.p.m.:	
50 lb./hr.	2½ Output is largely dependent upon application and cooling characteristics of take-off equipment. See text.
150 lb./hr.	3½
400 lb./hr.	4½
Recommended L/D	15:1 minimum: 20:1 recommended.
Recommended screw type	Full-flighted with metering tip.
Compression ratio[1]	4:1
Lead ratio[2]	1:1 for constant pitch screws.
Screen pack	Depends on application. (See text on "Screen pack," p. 662).
Drive power for 150 lb./hr., hp.	25. (Varies as a function of melt temperature and heater input to resin.)

B) *Operating conditions*

Flow	*MH*	*H-3*	*H-4*	*H-6*
Rear-cylinder, °F.	360	390	400	440
Mid-cylinder, °F.	380	400	410	450
Front-cylinder, °F.	400	410	420	460
Die, °F.	390	400	410	440
Screw water	Dependent on the screw design			
Feed section	Water cooled			
Melt temperature, °F.	390	400	410	430
Melt pressure at die	600 to 5000 p.s.i. depending on the restrictions designed in the die			

The above figures are general and should be adjusted for differences in formulation and application.

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[1] Compression ratio $= \frac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[2] Lead ratio $= \frac{\text{Distance between corresponding points on successive turns of same flight}}{\text{Inside diameter of barrel}}$

Water baths at 120 to 140° F. are used for monofilaments. The die should be as close to the water level as possible to control draw-down.

Cooled metal rolls are used to cast extruded sheet and film. The roll finish is imparted to the side of the web in contact with it. Polished surfaces with chrome or nickel plating are generally preferred. Temperature control may be by steam and water, hot circulating oil, or recirculating water system through the interior of the roll. The temperature of the roll is governed by the thickness of the sheet being extruded. The general range is from 160 to 260° F.

Future trends

In common with other popular thermoplastic materials, the cellulosics are being faced with demands for higher quality at reduced costs.

Valved high-pressure extrusion technique with new developments in high-speed extrusion and improvements in instrumentation and take-off equipment appear to offer further possibilities for the future in extending and improving the quality of this group of materials and bettering their economic position.

EXTRUSION: TFCE resins

By J. A. Jupa*

High polymers of trifluorochloroethylene, TFCE resins can be used at temperatures up to 392° F. and as low as —320° F. Also, it has been reported that TFCE has been used at temperatures approaching absolute zero. The material is nonflammable and possesses excellent weathering resistance, zero moisture absorption, toughness, transparency, excellent electrical properties, fungus resistance, and chemical inertness. Molding materials are supplied in the form of plasticized and unplasticized powders. These molding powders for extrusion purposes exist in the form of high-density granules or pellets (60 lb./cu. ft.) or low-density powder (19 lb./cu. ft.). Although both high- and low-density powders can be used for extrusion, the high-density powders are more commonly recommended. The molding powders are identified by grade numbers, e.g., Kel-F[1] 270, 300, and 500 plastics. In instances where greater flexibility is desired, plasticized material (for example, Kel-F grade 300 P-25) is most commonly used; the amount of plasticizer could be varied to suit the application.

Equipment for extrusion

General requirements for extruding TFCE are given in Table I, below. More specific details are discussed below.

TFCE has been extruded on most of the commercially manufactured machines. Minor machine modifications specific to TFCE might be necessary to insure high quality of extruded products. For the most part, electrically heated extruders are used which are able to maintain uniform temperatures between 300 and 675° F. Maintenance of uniform temperature is most important since the character of the profile is dictated by its thermal history within the extruder. A system of heat control which maintains a constant balance between the heat lost to the plastic melt and the heat introduced by the heating system would approach ideal operating conditions. The temperature fluctuations should be kept to a minimum in the range of ±2° F. along the length of the barrel and die. It is particularly important to keep the die temperature constant. An excess of 10° F. at the die can cause excessive material breakdown. Such breakdown can be prevented by dropping the temperature again.

The contact surfaces of the barrel can be Xaloy 306, high chrome-nickel stainless steel, Duranickel, or chromium-plated steel.

With the exception of Xaloy 306, the contact surfaces for screws should be the same as the extruder barrel surfaces. Two types of screws have been found to be satisfactory: conventional full-flighted screws having uni-

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* Industrial Plastics and Equipment Co., Elizabeth, N. J.

[1] Trademark of Minnesota Mining & Mfg. Co.

TABLE I: Requirements for extrusion of trifluorochloroethylene

A) *Machine characteristics*	*Sheeting*	*Wire coating*	*Shapes*	*Pipe*
Recommended L/D	(16 to 25):1	(16 to 25):1	(16 to 25):1	(16 to 25):1
Recommended screw type	Metering and conventional	Metering and conventional	Metering and conventional	Metering and conventional
Compression ratio[1]	2:1	2:1	2:1	2:1
Lead ratio[2]	1:1	1:1	1:1	1:1
Screen pack, mesh numbers in direction of flow	40,60,100	40,60,100	40,60,100	—
B) *Operating conditions*				
Melt temperature at die, °F.	580-590	580-590	580-590	580-590
Approx. melt pressure at die, p.s.i.	2000-3000	2000-3000	2000-3000	2000-3000
Screw cooling medium	Air	Air	Air	Air
Feed preheating	Unnecessary	Unnecessary	Unnecessary	Unnecessary
Metal temperatures, °F.				
Rear cylinder	400-450	400-450	400-450	400-450
Halfway along cylinder	450-475	450-475	450-475	400-475
Forward cylinder	500-550	500-550	500-550	500-550
Die	550-650	550-650	550-650	550-650
Is extrudate water quenched?	Yes	Yes	Yes	Yes
Water temp., °F.	50-70	50-70	50-70	50-70
Air gap, in.	2-10	36-48	2-10	2-10
Time in water, sec.	30-60	30-60	30-60	30-60
Draw ratio[3]	Variable	Variable	Variable	Variable

[1] Compression ratio $= \frac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[2] Lead ratio $= \frac{\text{Distance between corresponding points on successive turns of same flight}}{\text{Inside diameter of barrel}}$

[3] Draw ratio $= \frac{\text{Cross-sectional area of die opening}}{\text{Cross-sectional area of finished (untrimmed) extrudate}}$

form pitch and increasing root diameter and metering-type screws with uniform pitch and increasing root diameter.

Compression ratios of 1½ and 2½ to 1 have been most commonly used. The contact surfaces should be smooth and highly polished with a radial clearance of 0.005 in. or less. Provision should be made to keep the hopper zone in the screw area relatively cool. This may be done with air or water. Excessive cooling in this area will place an unnecessary load on the drive mechanism and most likely will be accompanied by "squealing."

Excessive heat in the hopper zone will result in premature melting of the TFCE molding powder and be manifested by loss of feed and bridging of the molding powder in the hopper. The hopper should be made of stainless steel or chromium-plated steel to prevent discoloration of the extrudate.

Extrusion rates of TFCE materials are lower than most common types of thermoplastics and it will be found that lower screw speeds are necessary. Therefore, provisions for screw speeds between 3 and approximately 30 r.p.m. should be considered. Screens are not usually necessary for extrusion of TFCE. However, to minimize the effect of surging and for more complete dispersion of color concentrates, a breaker plate with ⅛-in. holes and screens between 40 and 100 mesh have been successfully employed.

Die design

The materials of construction of the die are similar to those recommended above for the barrel of the extruder with the exception of Xaloy 306. For many rod and tube applications, die dimensions approximately 10 to 15% greater than the nominal size will be satisfactory. This should result in extrusions that have a low degree of strain. However, for increased production rates, less critical control problems, and in cases where the higher degree of strain is desired, the drawdown ratio can be scaled up accordingly. The most commonly used drawdown ratio is 3 to 1 but ratios as high as 12 to 1 have been used for certain types of work. Figure 1, above, shows a straight in-line tubing die; some suggested die dimensions for tubing are contained in Table II, below. To maintain optimum properties in the final extruded piece, the highest temperatures should be concentrated at the exit portion of the die. This is accomplished by extending the die bushing 1 to 4 in. between the die head and using a band heater on this bushing to control the heat independently. It is most important to have very accurate and uniform control of the die temperatures. A minimum number of "spider" legs should be used.

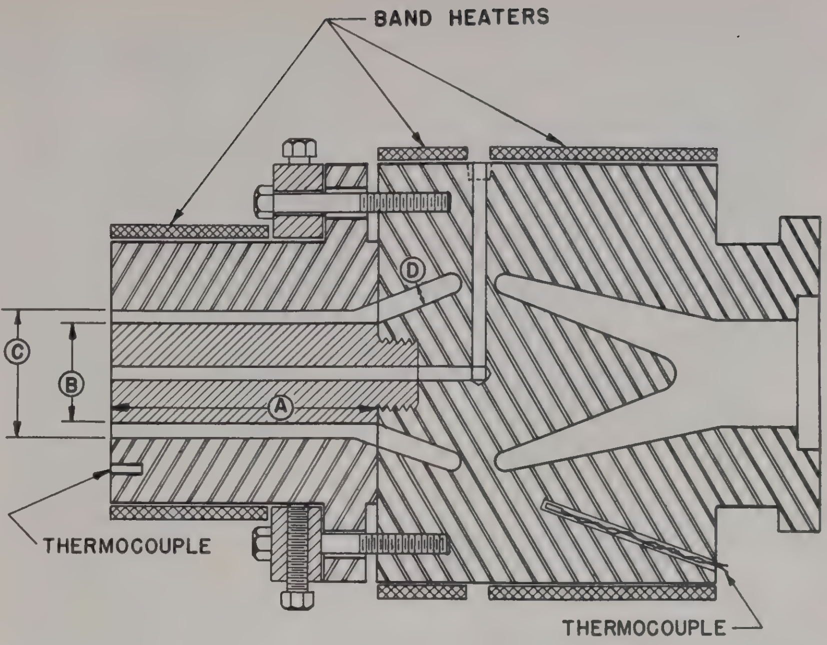

FIG. 1: Straight in-line die for extruding TFCE tubing. Suggested dimensions for this type of die are given in Table II, below

Wire insulation

The high-melt viscosity of TFCE requires the use of tube-on techniques, rather than the conventional pressure type extrusion methods used on vinyls and other more highly plasticized thermoplastics. The use of the tube-on techniques eliminates the restrictive effect of small die sizes. By this method, the die sizes can be increased appreciably and the oversized tube drawn down onto the wire at the time it leaves the die.

Considerable progress has been made within the last year on the die design most suitable for wire insulation with TFCE and some basic principles have been established. Fig. 2, p. 666, shows correct and incorrect designs. The correct design stresses the minimum restriction to flow within the die to the land area. This allows the use of maximum pressure within the die and positive movement of the material. An enlarged view of the tip shows the land area has been moved back along the mandrel for a short distance and the guider itself has been tapered. The die bushing essentially leaves the land area in

TABLE II: Suggested die dimensions for TFCE extrusion

	Tube size, O.D. in inches	
	1/16 to ½	½ to 1¼
A[a]—Land length, in.	1 to 2	2 to 3
B[a]—Mandrel diameter, O.D.	3 times nominal inside diameter	
C[a]—Die bushing, I.D.	0.180 to 1.50	1.50 to 3.75

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[a] The letters A, B, and C refer to the same locations as the letters in the drawing, Fig. 1, above.

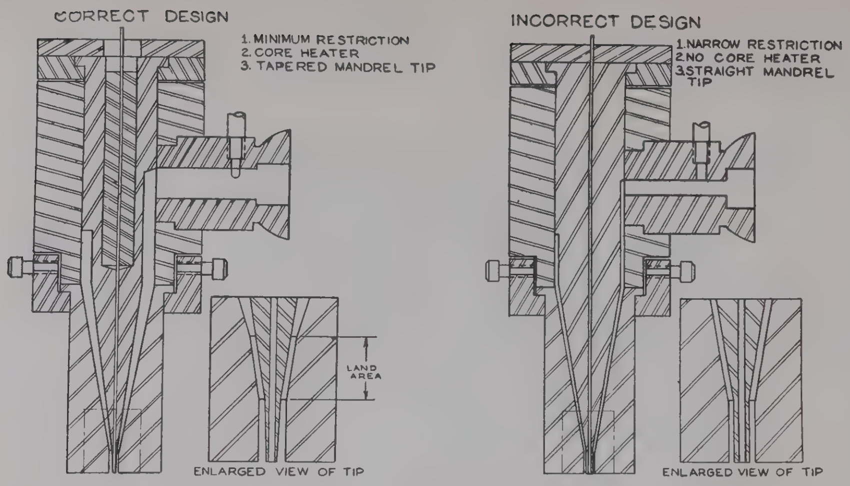


FIG. 2: Correct and incorrect designs for cross-head die to be used for extruding trifluorochloroethylene wire coating

a straight line. The use of a tapered tip shortens the length of the cone leaving the die, giving improved centering and lower shrinkage or strain. The use of an internal or core heater is recommended wherever possible. This allows the over-all temperature of the plastic melt to be reduced and minimizes the effect of material breakdown. However, it seems that satisfactory work has been accomplished both with and without the employment of an internal heater.

In the past, vertical extrusion has been recommended. However, using the new die design, a shorter plastic cone is obtained and horizontal extrusion is possible.

Horizontal techniques fit in with most wire insulating setups. For horizontal wire coating, there has been added a device on the entrance side of the die which will maintain the wire temperature close to that of the TFCE plastic leaving the die and a furnace on the exit side of the die to permit normal shrinkage above the transition point (417° F.). The use of a wire heater should not be overlooked. Formerly, minimum quench distances were recommended; that is, it was recommended that the wire be quickly quenched in water as soon as possible after leaving the die. More recent work has shown that a quench distance of three feet or possibly more results in lower shrinkage on the wire. The lower shrinkage, which amounts to 45% or less, does not develop flareback when it is tested in accordance with the solder-dip test of MIL-W-16878.

All other accessory equipment, such as pay-off capstan, spark-tester, and take-up are of conventional design.

Operating temperatures

In the final analysis, the actual cylinder temperatures may be ±25° F. or thereabouts of the suggested temperatures. It is important to have a reasonable temperature differential between various heating zones so that the controlling effect is of a positive nature. The final temperature settings will be determined by the character of the extruded profile. Excessive temperatures are being used when material develops numerous bubbles. The temperatures are too low when the extruded profile is lumpy, rough, or has a snake-skin appearance. The correct temperatures are attained when the extruded profile is smooth, transparent, and clear after it leaves the die. It is most important to use the lowest practical temperatures. At 500° F. material temperature, TFCE will not develop any significant material breakdown in one to two hours. At a temperature of 550° F., TFCE would not suffer any excessive breakdown within a half hour or less. In the neighborhood of 600° F., significant breakdown could take place within minutes. Therefore, it is important to keep the higher temperatures near the exit portion of the die where the contact time is reduced to a minimum. As indicated above, material breakdown is a function of the time and temperature; that is, the rate of material breakdown increases with temperature and with time at any fixed temperature.

Product quality

TFCE is essentially a crystalline material. The degree of crystallinity can be modified by various heat treatments. Within certain limits, if a clear transparent tube is required, quick quenching in water is recommended; however, if it is desired to increase the rigidity of the tubing, a more crystalline or more slowly cooled medium is suggested. Normally, cooling the extruded profile in air will serve to increase the degree of crystallinity and the general stiffness of the product. However, a subsequent and prolonged heat treatment can induce further crystallinity. Good clarity by quick quenching can be expected in profile thicknesses up to ⅛ in.; beyond this section thickness, the clarity gradually diminishes to a translucent effect.

Quality control

The useful life of any extruded plastics article is to a great extent a function of its retained or residual molecular weight. Therefore, minimum breakdown in the extrusion process should be considered a desirable goal. The extent of material breakdown during extrusion can be measured with various devices. In the case of TFCE, the ZST apparatus has been found very useful as a quality control device. In this device, a prepared test specimen with a double notch at the center is suspended in a constant temperature chamber with a fixed weight suspended from one end. The period of time in seconds required for this specimen to break is a measure of its relative molecular weight. The higher the value in seconds, the higher the molecular weight; the lower the value, the lower the molecular weight. This device makes it possible to maintain uniform quality of extruded products.

EXTRUSION: TFE resins

By Wallace B. Thompson, Jr.*, and Richard W. Johnson*

Early in the history of TFE (tetrafluoroethylene) resins, the combination of thermal stability and chemical inertness indicated that they could be used more advantageously than other materials for: 1) making tubing and hose to convey corrosive liquids having a wide range of temperatures and 2) for high-temperature wire insulation.

Initially, limitations were imposed on the production of these forms because the resin could not be melt-fabricated even at temperatures above its crystalline melting point of 620° F. (327° C.). Experimental work with Teflon[1] 6 TFE resin in Du Pont laboratories resulted in the development of a simple and unique technique for overcoming these limitations.

This technique is based on blending an extrusion aid or lubricant with the tetrafluoroethylene resin and preforming the mixture to a cylindrical billet by compression at 100 to 300 p.s.i. for use in a ram-type extruder. The composition is forced through a forming die by the ram, the extrusion aid is vaporized (at 200 to 575° F.), and the extrudate is sintered and cooled.

Sifting the resin through a 4-mesh screen is recommended prior to blending. Since excessive working is deleterious to the polymer at this point, the sieve should be vibrated just long enough to allow most of the fine powder to pass through.

The main requirements of a good extrusion aid are: 1) ease of incorporation into the resin and 2) complete and rapid volatilization below the sintering temperature with little or no carbon formation.

VM&P grade naphtha[2] is recommended for general use as an extrusion aid. White oil has also been used extensively.

The amount of extrusion aid which is required varies with the type of liquid used and the geometry of the extruder. Some experimentation will be required to determine the optimum conditions. Generally, 19 to 25 parts per 100 parts of resin are needed. Precautions should be taken to avoid fire when using naphtha.

The steps in compounding are:

1) Provide a clean, dry container of suitable size and proportions with a tight closure. For a 1000-g. batch of Teflon, a 1-gal., wide-mouth bottle is suitable.

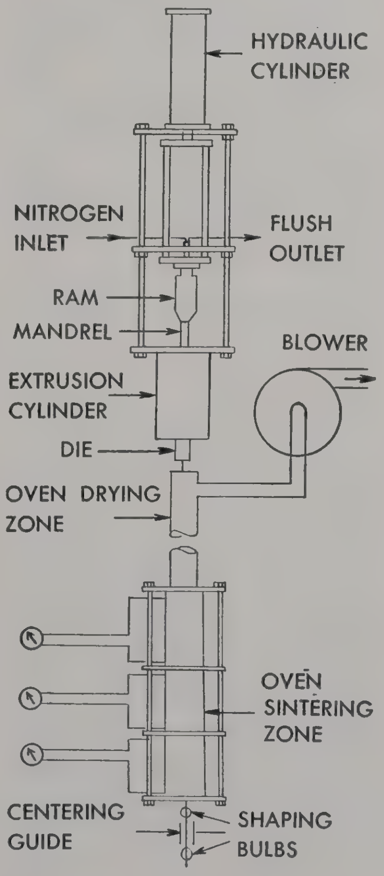
2) Weigh the required quantity of sifted TFE resin and pour it into the container. Add the weighed quantity of extrusion aid, taking care that the liquid does not wet the walls of the container.

3) As soon as the extrusion aid is absorbed, close the container and shake to minimize wetting container walls with liquid.

4) Place the container on a suitable rolling device. (For a 1- or 5-gal. bottle, 20 min., at 15 r.p.m. is recommended.)

5) Store the blend for 24 hr. to allow a uniform distribution of the extrusion aid throughout the powder.

FIG. 1: Diagram of ram extruder for producing TFE tubing



Preparation of preform

To prepare the preform, a cylinder is used which has a core and a closure plug. The dimensions of the cylinder and core should allow for a 20- to 30-mil radial clearance between the preform and the walls of the extruder cylinder and its mandrel. It should also be at least 2¼ times as long as the preform since the compression ratio of the compounded resin is about 2.25:1.

A weighed quantity of the blended material is poured into the cylinder and uniformly distributed around the core. The closure plug is then inserted and pressure is built up to 100 to 300 p.s.i. on the stock over a period of about 3 minutes. The peak pressure should be maintained for about ½ min. and the pressure slowly released. Great care should be used in pushing the preform out of the die.

After the preforming step, the paste extrusion of tubing and wire coating are different processes and require different equipment and techniques. The two processes are discussed separately in the following sections.

Tubing extrusion equipment

The basic equipment (see Fig. 1, left) used for the extrusion of tubing from compounded resin consists of a ram, a mandrel over which the ram travels, a cylinder, and a die.

A hydraulic piston is preferred as a device for driving the ram, although a screw-jack has been successfully employed to drive small-diameter rams. Equipment capable of providing 10,000 p.s.i. at the ram face should be adequate for most applications.

For small tubing, the extruder may be either horizontal or vertical, but for tubing more than 1 in. in diameter, it should be vertical. The mandrel forming the bore of the tubing can be straight or tapered at the approach to the die land. The die is normally tapered

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* Polychemicals Dept., E. I. du Pont de Nemours & Co., (Inc.), Wilmington 98, Del.

[1] Trademark of E. I. du Pont de Nemours & Co., (Inc.)

[2] VM&P naphtha of specific gravity 0.735 to 0.749; boiling range 194 to 248° F.

References were prepared by the editors.

TABLE I: Data for TFE tubing extrusion

Cylinder diameter	*Tubing size O.D.*	*Wall*	*Reduction ratio*	*Die taper*	*Land length*
in.	*in.*	*in.*		*incl. angle, °*	*in.*
6	4	0.060	35:1	60	14
6	3	0.060	50:1	60	12
6	2	0.060	70:1	60	10
6	1	0.060	135:1	60	8
6	½	0.045	410:1	60	6
4	¾	0.030	600:1	30	4
4	⅛	0.030	1400:1	30	3

from the diameter of the cylinder down to the size required for the tubing.

The die land should be long enough to prevent curling or swelling of the extruded piece and to provide enough back-pressure to form a dense product. Table I, above, lists recommendations for land length and die taper angle for tubing extrusion.

Tubing extrusion operation

The extrusion process is carried out on a batch basis. The machine must be stopped after each preform has been extruded and a new preform inserted.

In starting up an empty extruder, a tube 2 to 3 in. long, carefully machined to the proper size, should be inserted in the die land from the discharge end of the die. It should fit snugly since it serves to center the mandrel with respect to the die body. When the stock of resin flows into the annular die land, the stock itself holds the mandrel in a centered position and pushes the positioning tube or centering ring out of the die.

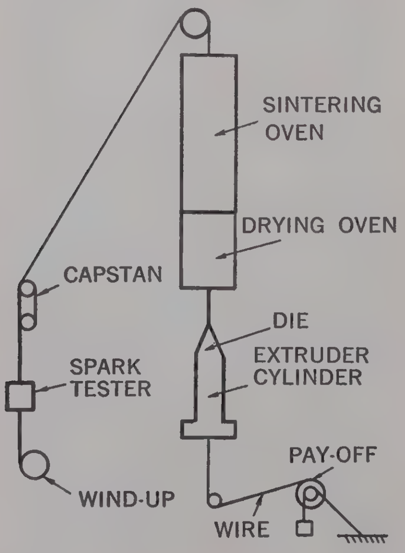

FIG. 2: Ram in cylinder extrudes TFE resin as wire coating

The pressure required for extrusion will vary, depending on machine design and processing conditions. Relatively high pressures are required if the concentration of extrusion aid is low, if the taper angle of the die is relatively large, if the land below the orifice is long, or if the ratio of the cross-section of the preform to that of the product (reduction ratio) is large.

If the pressure required is too high, the capacity of the machine may be taxed or the tubing may be excessively oriented so that it tends to develop longitudinal splits. If the extrudate is produced under too low an extrusion pressure, it may be weak and porous. This can be corrected by reducing the amount of extrusion aid used or by altering the die and cylinder geometry to increase back pressure.

Drying and sintering of tubing

The tubing leaving the extrusion die is first heated for a sufficient length of time to evaporate the extrusion aid. Initial oven temperatures only slightly higher than 200° F. are used for thick cross-sections. Temperatures up to 575° F. can be used for thin walls (such as 15 mils). The tubing temperature should reach 700 to 750° F. in the sintering zone.

Removal of volatile extrusion aid should be done at a slow rate to prevent blistering. With naphtha as extrusion aid, less than 5 min. is required for small tubing; up to 20 min. for 2-in. tubing with 60-mil wall.

The additional heating time required for sintering is approximately the same as that required for volatilization when the heat source is hot air. The use of infra-red heat reduces this time.

As much as 40% shrinkage, most of which occurs in the machine direction, may take place. Wall thickness changes are small.

The time the resin should remain in the amorphous state at temperatures above 620° F. must be determined experimentally and depends partly on the degree of longitudinal orientation produced during extrusion. The major portion of this orientation must be destroyed so that the finished tubing will have adequate strength in the circumferential direction.

Tubing over about 1 in. in diameter tends to distort out of round during sintering and cooling. This can be minimized by suspending shaping bulbs from the end of the mandrel at a point just below the sintering zone. These bulbs should be smooth, round in cross-section, and ⅛ to 3/16 in. smaller than the inside diameter of the tubing.

For tubing over 1 in. in diameter, nitrogen should be flushed through the tubing via a suction system connected through the mandrel to remove extrusion aid vapors inside of the tubing.

Wire coating equipment

The equipment used for the extrusion of wire insulation from compounded TFE resin (see Fig. 2, left) consists of an extruder cylinder and ram, a die, a drying and sintering oven, and standard wire coating pay-off and wind-up machinery.

The ram is driven by a screw-jack mechanism which enables a constant throughput of resin regardless of extrusion pressure. This constant delivery is required to insure good caliper control of the extrudate. Cylinder and ram should withstand extrusion pressures as high as 30,000 p.s.i.

The die (see Fig. 3, p. 669) is used to form the compounded preform into a strong fibrous coating with the desired wall thickness on the wire. The variables affecting the die performance are as follows:

1) The degree of included angle

of the die cone; 2) the diameter of the die land; 3) the length of the die land; and 4) the temperature of die during extrusion.

The included angle of the die cone affects the extrusion pressure and the smoothness of the extrudate. A 20° included angle die appears most suitable, particularly for thin-wall coating of hook-up wire. Dies having an included angle of 30° are used for thicker wall insulations.

The die land diameter is the basic determinant of the extrudate diameter. Generally, the die land diameter should be about 5 to 20% less than the extrudate diameter. The extrudate diameter can be calculated to ± 1 mil by using equation (1) which was derived for the extrusion of Teflon 6 using No. 30 white oil or VM&P naphtha as an extrusion aid. The extrudate diameter is related to the volumetric displacement rate of the ram and the wire coating speed by equation (2).

$$\frac{D_E^2 - D_W^2}{D_P^2 - D_W^2} = 0.944 + 2.85\,\frac{X}{1 - X} \qquad (1)$$

$$V_R = \frac{3\pi}{10^6}\,(D_E^2 - D_W^2)\,S_W \qquad (2)$$

where: D_E = extrudate diameter in mils; D_P = product diameter in mils; D_W = conductor diameter in mils; X = lubricant concentration in g./g. of lubricated tetrofluoroethylene; V_R = volumetric displacement rate of ram (cu. in./min.); and S_W = wire coating speed in ft./minute.

The length of the die land affects the surface smoothness of the extruded coating. In general, the longer the die land, the smoother the coating, but die land length is limited by shear imposed by the wire which causes the coating to tear when land length is excessive. In practice, die land lengths from ¼ to ½ in. produce an extrudate with a smooth surface, free from tears.

The temperature of the die during extrusion should be maintained between 80 and 140° F. Heating the die aids the drying operation by preheating the extrudate, which increases the rate of diffusion of the lubricant to the surface of the coating where it can be vaporized.

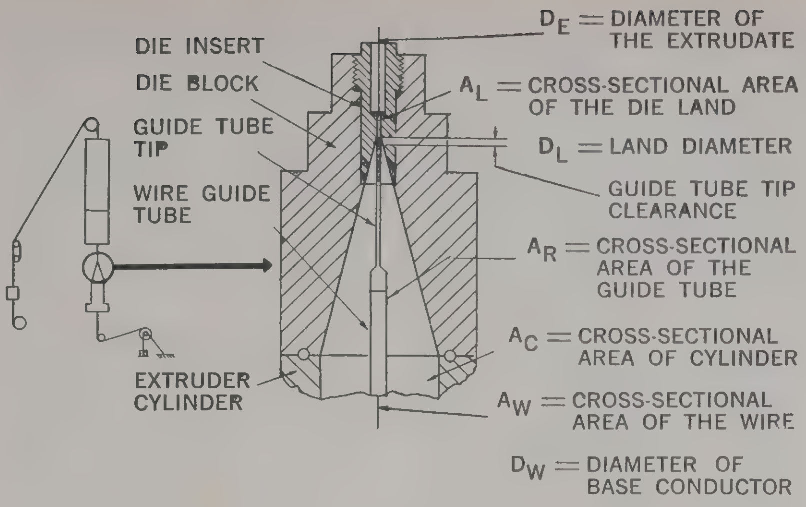
DIE INSERT
DIE BLOCK
GUIDE TUBE TIP
WIRE GUIDE TUBE
EXTRUDER CYLINDER
D_E = DIAMETER OF THE EXTRUDATE
A_L = CROSS-SECTIONAL AREA OF THE DIE LAND
D_L = LAND DIAMETER
GUIDE TUBE TIP CLEARANCE
A_R = CROSS-SECTIONAL AREA OF THE GUIDE TUBE
A_C = CROSS-SECTIONAL AREA OF CYLINDER
A_W = CROSS-SECTIONAL AREA OF THE WIRE
D_W = DIAMETER OF BASE CONDUCTOR

FIG. 3: Die for extrusion-coating wire with TFE resin. See also Fig. 2, p. 668, and discussion of dimensions in text at left

The guide tube and tip provide a guide for the wire through the extruder cylinder to the entrance of the die land. The clearance between the die land entrance and the guide tube tip can be varied to control the length of wire exposed to the polymer in the die.

Wire coating operation

Wire coating extrusion, like the extrusion of tubing, is carried out on a batch basis. The pressure required is highly dependent on the reduction ratio which is a direct measure of the shear or deformation imposed on the resin particles. This ratio is defined as the ratio of the cross-sectional area of TFE in the extruder cylinder to the cross-sectional area of TFE in the die land. Referring to Fig. 3, above, the equation (3) for reduction ratio is:

$$RR = \frac{A_C - A_R}{A_L - A_W} \qquad (3)$$

In practice, successful fabrication is limited by the upper and lower extremes of reduction ratio. At reduction ratios of 2000 to 3000, fracture of the polymer may occur in the die, resulting in an extrudate sheared into discontinuous pieces. At reduction ratios around 100, the particles are not elongated sufficiently to be suitable for wire insulation. These limits also depend on the extrusion aid concentration and the insulation construction in question and are therefore not specifically definable.

The clearance between the guide tube tip and the entrance to the die land is also an important factor in this process. If this clearance is properly set, the average velocity of the lubricated polymer in this area is the same as the wire speed. If the clearance is too large, the polymer speed is slower than the wire speed, which causes excessive shearing of the polymer particles in contact with the wire. This shearing action increases the wire tension enough to break the wire and causes numerous coating flaws. Should the clearance be too small, the guide tube tip tends to plug the die, causing high extrusion pressures. This plugging action causes surging of the lubricated polymer around the wire, which will, in turn, result in rough, discontinuous coatings. In addition, if the guide tip is set high enough to extend into the die land, the insulation will be "tubed" onto the wire. This will cause loose coating.

The drying and sintering of wire insulation is accomplished in the following manner:

The extrudate leaving the extrusion die contains about 19% by weight or 40% by volume of naphtha. In the drying oven this extrusion aid diffuses to the surface of the coating and is vaporized. It is important that all the vaporization of the extrusion aid take place on the coating surface to prevent cracks. The rate of diffusion and vaporization is controlled by the drying oven temperature. Drying oven temperatures generally used are about 300° F. at the entrance up to 575° F. at the exit. During drying, the oven should be exhausted sufficiently to keep naphtha fume concentration below 0.9 percent.

The coating leaving the drying oven is very porous. The forces of coalescence in sintering are strong enough to eliminate these voids with a reduction in the coating diameter. The coating must reach a temperature above 621° F. for a few seconds to effect this sintering. While the resin is in the gel state (621° F.) it should not be submitted to stresses. To enable the coating to be sintered properly, the sintering oven is maintained at 700 to 750° F. The sintering oven should be equipped with an exhaust system to remove possible trace quantities of toxic fumes given off during sintering or from coated wire left inadvertently in the hot ovens.

Adequate ventilation is a recommended precaution against the inhalation of small amounts of gaseous decomposition products encountered when processing Teflon TFE resins at temperatures above 400° F. (204° C.). There are no known cases of ill effects where suitable precaution has been exercised.

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EXTRUSION: FEP resins

By Harry J. Haon III*

Developed by the copolymerization of tetrafluoroethylene and hexafluoropropylene, FEP resin, a fluorocarbon polymer, softens at about 550° F. and is readily extruded at temperatures of 600 to 745° F. Its melt viscosity, one millionth that of TFE-fluorocarbon resin, permits fabrication by conventional melt extrusion and (see p. 619) injection molding.

Conventional melt extrusion equipment can be used in processing FEP resin.[1] A metering type, rapid-transition screw is recommended. In order to assure uniform melting and constant delivery, the metering section of the screw should comprise about 25% of the total screw length. The depth of the channel is shallowest in this section (e.g., approximately 0.110 in. for a 2 in. extruder). The end of the screw should be designed with a slight conical or rounded nose to minimize resin hold-up.

A breaker plate is used with as many holes as possible approximately ⅛ in. in diameter. The entry and exit sides of each hole should be streamlined by tapering or countersinking. If contamination of the resin is avoided, and if a metering-type screw of proper design is used, screens are seldom needed.

Use of a spider type die should be avoided since any resulting dead spots may become filled with degraded polymer that can contaminate the product. Streamlining of all flow channels and a well aligned fit between each part of the adaptor and die system are also suggested.

For extrusion of FEP resin on a production basis, satisfactory product quality and equipment life will depend on the use of corrosion resistant metals. The most promising material to date is Hastelloy[2] C. A screw, breaker plate, cross-head and die parts made of this material used in combination with a barrel liner of Xaloy[3] 306 provide excellent insurance against corrosion and product contamination. Other materials, including various stainless steels, have been tried, but sufficient data to judge their relative performance have not as yet been gathered.

Extruders used with FEP resin should be electrically heated, preferably with heater bands rated at 25 to 30 watts/sq. in., and capable of reaching 800° F. It is desirable to divide the barrel into several independently controlled heating zones, each with its own controlling thermocouple and temperature indicating device. The die and any adaptors should also have separately controlled heater bands.

Because of the need for precise temperature control in extruding FEP resin, use of a melt temperature measuring thermocouple is beneficial. This thermocouple should be located in the melt, down stream from the breaker plate and and as close to the die as possible without presenting a serious restriction to polymer flow.

In addition to standard auxiliary equipment, a hooded exhaust with an exhaust capacity of about 100 c.f.m. should be placed over the extruder die and hopper and used whenever operating. Above 400° F., FEP resin releases small quantities of unhealthy vapors in substantially the same way as other halogenated resins, and therefore good ventilation of the processing equipment is required.

Processing techniques

The flow rate of molten polymers through dies is limited by surface roughness caused by the phenomenon of melt fracture which occurs above a certain critical shear rate. Because of its relatively high melt viscosity, FEP resin undergoes melt fracture at somewhat lower extrusion rates than other thermoplastics.

While FEP resin is prone to melt fracture, it also exhibits a high capacity for drawing in the molten state. By extruding the resin at moderate speeds through dies of large cross-section and then drawing the molten extrudate to the desired shape, production rates are comparable to

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*Polychemicals Dept., E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.

[1] Information in this article is based on work with Teflon 100, a general-purpose extrusion and molding resin. Teflon is a trademark of E. I. du Pont de Nemours & Co., (Inc.).

[2] Trademark of Haynes-Stellite Co., Div. of Union Carbide Corp.

[3] Trademark of Industrial Research Laboratories, Inc.

TABLE I: Extrusion of FEP-fluorocarbon resin

A) Machine characteristics	*Wire coating*	*Small diam. tubing (up to ⅜ in.)*	*Hose-size tubing (up to 1 in.)*
Recommended machine size, in.	1½ to 2½ in.	1½ to 2½ in.	1½ to 2½ in.
Recommended L/D	>15:1	>15:1	>15:1
Recommended screw type	metering, constant-pitch, rapid compression		
Compression ratio[1]	3:1	3:1	
B) Operating conditions			
Melt temp. at die, °F.	720-745	600-650	720-745
Melt pressure at die	100-1000	500-2500	100-1000
Screw cooling	not recommended		
Entering temp., °F.	room temp.	room temp.	room temp.
Metal temp., °F.			
Rear cylinder	500-600	500-550	500-600
Halfway along cylinder	650-700	600-620	650-700
Forward cylinder	700-735	610-625	700-735
Die	720-740	610-650	720-740
Is extrudate water quenched?	Yes	Yes	Yes
Water temp., °F.	50-70	50-70	50-70
Air gap, in.	4-8	2-4	—
Draw ratio[2]	10 to 150	3 to 30	—

[1] $\text{Compression ratio} = \dfrac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[2] $\text{Draw ratio} = \dfrac{\text{Cross-sectional area of die opening}}{\text{Cross-sectional area of finished (untrimmed) extrudate}}$

those achieved with other resins. This technique has allowed extrusion of such shapes as hook-up wire insulation at linear rates as high as 650 ft./min.

Wire coating

FEP resin is particularly well suited for providing smooth wire coatings and with proper wire handling equipment, no limits have been apparent as to the diameter or shape of the core to be coated. Coating thicknesses of 3 to 30 mils have been extruded over such materials as silicone rubber, polyvinyl chloride, neoprene, Teflon TFE resins, glass braid, and metal shielding.

In extruding FEP resin as a primary insulation or cable jacket, high production rates are achieved by extruding a tube of resin having a larger internal diameter than the base wire construction and a heavier wall thickness than the final insulation thickness and then drawing the large tube down to desired size. Slight vacuum may be applied to the inside of the extruded tube through the wire guide to facilitate drawing of the molten tube down tightly onto the base construction. Tubing dies which result in an area drawdown of about 100:1 are desirable for coating hook-up type wire and wire constructions up to ⅛ in. in diameter. On the other hand, drawdowns as low as 10:1 may successfully be used for jacketing cables greater than ½ in. in diameter.

Long land dies are desirable when coating wire with FEP resin. Land lengths about 10 times the radial clearance between the die and guider tip should be sufficient. Long land dies help to reduce surging and increase rates of extrusion.

For wire coating, FEP resin should be run as hot as possible short of degradation to yield the smoothest possible surface. A stock temperature range of 720 to 745° F. is preferred. Overheating may cause discoloration of the stock, bubbling, or both.

Tubing extrusion

Spaghetti tubing can be produced by a free-extrusion technique in sizes below about ⅜ in. in diameter and in the range of 10 to 30 mils wall thickness. The free-extrusion process consists of extruding a tube, drawing this tube down to size as it emerges from the die annulus, and pulling the tubing through a cold water quench tank or trough by means of a set of variable-speed rubber pinch rolls. Compressed air or nitrogen gas is admitted through a small hole in the mandrel so that a low positive pressure can be maintained inside the tubing as it is extruded to prevent collapsing and to aid in controlling size. Stock temperatures in the range of 610 to 650° F. are desirable.

Because of the lower stock temperatures used, draw-downs for extruding spaghetti tubing of FEP resin will be considerably less than those used in wire coating and will range from 3:1 to 30:1. Draw-down less than 3:1 will not supply sufficient melt tension for shape retention; draw-downs greater than 30:1 may result in tear-offs of the molten tube.

Hose-size tubing from ⅜ to 1 in. in diameter may be produced by conventional "forming box" techniques wherein the molten resin (suggested stock temperature, 700 to 740° F.) is passed through a relatively long die land and then immediately into a water jacketed cooling chamber where it is expanded to size by air pressure. Special care is needed in all extrusions of FEP resin to keep the die lands from chilling and thus causing sheared rough surfaces on the extrudate. To minimize heat transfer from the die to the cooling box, there should be a heater band on the outside of the die land and minimum metal contact between the die and the box.

For tubing with a wall thickness of ⅛ in. or less, a 4-in. long forming box is normally sufficient. Upon emerging from the forming box, the tubing has good form stability, although the inside portion of the tube wall may still be molten. It is desirable to cool the product further by passing it through an open-water quench tank.

Other techniques

Rod stock may be extruded from FEP resin if means of cooling are provided to control the shape and help avoid bubble formation or shrinkage voids. Cooling can be accomplished by attaching a water jacketed extension much like a forming box on the face of the die. In making rod stock, the cooling chamber is relatively long, and even so, cooling capacity may be the rate limiting factor.

An external brake or artificial back pressure should be applied at the start-up and during extrusion of rod stock. Thus the melt is prevented from puddling in the cooling chamber and bubble formation is eliminated.

Shapes such as moldings, beadings, channels, etc., can be extruded from FEP resin. For example, a channel shape has been made where the side walls are ¾ in. high and the thickness is .060 in. Consideration must be given to shape retention during cooling.

Blown bottles: Because of its viscosity and melt draw characteristics FEP resin handles well in bottle blowing operations.

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EXTRUSION: Flexible polyvinyl chloride

By G. F. Cohan*

The fact that polyvinyl chloride can be plasticized makes possible the production of a wide variety of formulations, all of which, from the very soft to the rigid, may be processed by extrusion. PVC does not have a sharp melting point but softens gradually with increasing temperature. The viscosity of the stock at extrusion temperatures is dependent on the amount of plasticizer and, to a lesser extent, on the type of plasticizer. As the amount of plasticizer decreases, the viscosity increases, thus requiring more heat and pressure to move the material and increasing the possibility of thermal degradation.

Material and equipment

Many polyvinyl chloride resins are offered today. They may differ in such properties as molecular weight, particle size and shape, and bulk density. The type of resin chosen is dependent on the finished properties desired and the type of compound and method by which it is prepared, i.e., mill mixing, Banbury mixing, or dry powder blending. Most extrusion is done with resins of high molecular weight since they provide the highest physical strength, best heat aging, and best low-temperature properties.

Plasticized polyvinyl chloride must be heated and worked mechanically to prepare it for final shaping by the extrusion die. The original method was to mix the stock on a two-roll mill and feed hot strip to the relatively short-barrelled extruder used in the rubber industry. This required substantial mixing equipment but made few demands on the extruder. With the advent of cold granular compounds previously mixed on the mill or in the Banbury, the extruder had to perform another function, i.e., heating and reworking the compound. To do this, barrels were extended to a ratio of length-to-screw diameter of 10 or 15:1 and screws were designed with shallower flights to provide greater shearing action.

Eliminating the milling process and preparing the basic ingredients in the form of a relatively dry, free-flowing powder left to the extrusion machine the entire job of applying heat and mechanical work. Thus, still longer cylinders, containing screws with shallower flights and higher compression ratios, were built. In addition, dual-screw machines can be used to perform the same function. The method of preparing and feeding the plasticized compound will determine the extruding equipment to be used.

Corrosion-resistant equipment is used because the main degradation product of PVC is hydrogen chloride, which attacks carbon steel. Cylinders are provided with corrosion-resistant liners, such as Xaloy. Screws are usually chrome-plated and some have Stellite flights. Though not necessary, it is preferable to chrome-plate dies.

Dies

Wherever practical, streamlined dies are preferred. With most profiles, flat-plate dies are used with a standard tapered approach which varies from 30 to 60°. Actual approach to the die land for extruding thin-wall wire insulation may be as low as 9°.

Dies are made 10 to 20% oversize, anticipating that the section will be drawn down to size. Flow patterns may be adjusted by changing orifice size as well as by varying the land length. Opening the approach to the land is the usual way to reduce its length. In general, as the sections being extruded grow larger, the lands must be lengthened to smooth out the flow. The rate at which material passes over the surface of the die also affects the length of land to be chosen.

Tubing or hose dies contain a hollow mandrel tapered at the approach end and held in place by means of spider legs, or extending from the rear of the die, without legs. Air is introduced through one of the legs and the mandrel to maintain the shape of thin-wall tubing or to expand the extruded tube in making blown film. Film dies may be either the circular-type, making an expanded tube which is later slit, or the flat-strip variety. The latter are more versatile but must be carefully designed to distribute flow across a wide area and still maintain uniform gage across the sheet.

Extrusion techniques

Since the basic functions of the extruder are to heat and work a compound before forming it, control of temperature and pressure is vital. External heat is applied by means of oil or electrically heated cylinders. The oil is also used as a cooling medium, while cylinders which are heated electrically are cooled by air or water. Frictional heat is generated internally by shearing action on the compound between the screw and the cylinder walls, the amount being determined largely by design of the screw and control of its temperature. Water or steam may be circulated within the screw for about two thirds of its length. Control of both inlet and outlet water temperature permits adjustment of stock viscosity and resulting frictional heat. Many high-speed extruders, particularly in the wire insulating field, are adiabatic; that is, they operate entirely on frictional heat.

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* Senior Representative, Plastic Material Sales, B. F. Goodrich Chemical Co., Div. The B. F. Goodrich Co., 3135 Euclid Ave., Cleveland 15, Ohio.
References were prepared by the editors.

Each compound requires a certain amount of physical working. The pressure developed on the stock between the end of the screw and the breaker plate gives an indication of the work being done. The pressures given in Table I, right, cover soft to rigid polyvinyl chloride formulations. More work is necessary as less plasticizer is required.

Several methods are used to develop necessary pressures. When die openings are small in relation to the size of the screw, the die itself may provide sufficient back pressure. In extruding insulation on wire, varying the space between the tip and die will help to control pressure on the compound. Also, longer die lands, finer screen packs, and cooler screws are used. More recently, restrictions ahead of the die have been employed to increase pressure. These include the use of a movable screw to vary the space between its tapered tip and the conical approach to the die, a needle-type valve between the breaker plate and die, a movable sleeve on the guider in wire insulating, and a choke bar in flat sheet dies.

These methods of increasing pressure reduce output and require higher screw speeds to maintain desirable rates of flow, thereby working the compound more and producing more heat. The screw speed attained will be limited by the dimensional tolerances and appearance of the finished product.

Since the extrusion machine provides an effective means of heating and working, it is also used to prepare stock for calendering and injection molding. In the latter case, flow temperatures are close to compound breakdown temperatures, so that development of stock temperature by internal frictional heat is preferable to external heating. It is difficult to attain the proper temperature by external heating since polyvinyl chloride is such a poor conductor.

TABLE I: Extrusion of polyvinyl chloride

	Flexible		*Rigid*
Material form	*Granules*	*Dry blend*	*Granules*
Screw			
Description	Single, full flight, constant pitch, increasing root diameter		
Ratio of length-to-diameter (longer screws are satisfactory)	10:1 min.	15:1 min.	15:1 min.
Depth of flight at delivery end of 3½ in. screw, in.	¼	⅛	¼
Compression ratio[1]	2:1	4:1	2:1
Pitch (distance between flights)	Approximately equal to screw diameter		
Operation			
Pressure, p.s.i. (between delivery end of screw and breaker plate)	1000-3000	1000-3000	2500-6000
Stock temperature, °F.	320-400	320-400	335-380

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[1] Compression ratio $= \frac{\text{Volume of material between flights at feed end}}{\text{Volume of material between flights at delivery end}}$

Cooling and take-up

Extruded profiles are drawn through a water cooling bath by means of a variable-speed endless belt. Slipping is prevented either by winding the shape around the belt or by weighted idler rolls. In some cases, parallel endless belts grip an extruded section between them and pull it forward. Insulated wire is pulled through a water bath by means of a variable-speed capstan. Water temperatures are usually 50 to 80° F.; two-stage cooling is also used.

Some profiles are allowed to cool before being put on reels, to prevent possible flattening of the section caused by contraction as the extrudate returns to ambient temperature.

In general, vinyl compounds do not pick up moisture and do not require predrying. A few dry powder blends containing hygroscopic ingredients may cause some porosity. However, most porosity in extrusions is caused by trapped air rather than moisture. If the compound is fluxing at the proper point along the screw, neither too close to the breaker nor to the hopper, the problem of trapped air will be lessened. Venting will eliminate volatiles, though it is difficult to control. This is done with multi-stage screws, with the vent above a deep flighted section where there is no pressure on the stock.

Purging

Purging is usually done with the same compound at a lower temperature or with a harder compound than the one being extruded.

References

For further information on vinyl materials, see p. 171; on extrusion equipment, see p. 656.

"What you should know about plasticizers for vinyls (molding and extrusion compounds)," by H. S. Bergen, E. E. Cowell, and W. Waychoff, MODERN PLASTICS *30,* 93 (Nov. 1953).

"PVC dry blend extrusion," by E. H. Hankey and R. D. Sackett, SPE J. *14,* 43 (March 1958).

"Compounding and processing rigid PVC," by R. J. Ettinger, SPE J. *9,* 16 (Feb. 1953).

"Blow extrusion of thin vinyl film," British Plastics *26,* 24 (Jan. 1953).

EXTRUSION: Nylon 6/6

By R. M. Bonner*

Extrusion compositions of 6/6 nylon resins are available in two melt viscosity ranges (i.e., 2500 and 50,000 poises at 550° F.)—both as unmodified compositions and as specially compounded resins designed for use in applications requiring improved heat life or weatherability. The lower-viscosity resins (e.g., Zytel[1] 101) are most suitable for use in processes which require a good flowing melt and thus are suggested for applications such as extrusion coating or rod extrusion. The high viscosity resins (e.g., Zytel 42) are most useful in processes which demand some form stability in the molten state such as blow-molding of bottles and extrusion of sheet, film, and profiles.

Extrusion equipment

Barrel and heating equipment: In keeping with the trend of the industry to attain higher extrusion rates, it is desirable to use a long barrel extruder for processing nylon. At the present time it appears that the ratio of the extruder-barrel length to its diameter should be at least 20:1 but need not be greater than ca. 24:1. Shorter barrel extruders will be more susceptible to problems such as surging, air entrapment, and inadequate plastication of the melt. Because most 6/6 nylon extrusion operations require barrel temperatures in the range of 550 to 600° F., electrical heaters are preferred to a hot oil heating system. Normally, the hopper section does not require water cooling; however, when necessary to protect the bearings, the minimum amount of water possible should be used. Excessive cooling of the hopper section may cause surging of the extrudate.

Hopper feed throat: In order to prevent excessive wedging of the resin particles between the land of the screw and the barrel wall, the direct overhead type of feed throat should be used.

The screw: The screw commonly used for processing nylon is a constant-pitch, rapid-transition (½ turn) metering type as shown in Fig. 1, p. 675. For the more viscous nylons, a gradual transition screw (e.g., about 10 turns for a 2½ in. extruder) may be used. Screws having no metering section or having too deep a channel in the metering zone may lead to difficulties with entrapment of air, improper plasticating of the melt, and surging of the extrudate.

Screen and breaker plate: If a breaker plate is used to support a screen pack, it is advisable to counterbore it on the up- and downstream sides to prevent excessive holdup (1).[2] An improperly designed breaker plate may cause the appearance of weld lines which may lead to reduced toughness of the extrudate. The screen pack requirement will vary with each specific job being run; however, a typical screen pack comprises two 120 mesh screens backed up by two 80 mesh screens. An insufficient screen pack may result in a bubbly extrudate due to entrapped air, surging of the extrudate, or insufficient plastication of the melt.

Extrusion operation

Drying: Since all nylon resins are hygroscopic, excessive exposure to the atmosphere can result in the absorption of sufficient moisture to cause a reduction in melt viscosity, bubbling of the extrudate, and reduced toughness of the extruded product.

The lower viscosity 6/6 nylon resins (e.g., Zytel 101) usually may be fed directly from the can to the extruder hopper. When using rework material or under unusual extrusion conditions (such as elevated temperatures or long hold-up time), it may be necessary to dry the resin prior to extrusion. The drying procedure, which involves a dehumidified air-circulating oven at 175° F., has been described (2).

The high viscosity 6/6 nylon resins (e.g., Zytel 42) are extremely dry and should be used directly from the can. To minimize contact with atmospheric moisture, the cans should not be opened until just prior to being loaded and the hopper itself should be provided with a tightly fitting cover. It is good practice to keep the amount of resin in the hopper below the amount needed for one hour's running.

Temperature profile-controller settings: The temperature-control point in nylon extrusion is the melt temperature as indicated by the stock thermocouple (3). This indicated temperature is controlled by regulating the extruder barrel temperatures. The extruder barrel temperature profile will depend upon a number of factors: the type of extruder (size and model), the wattage of the heater bands, placement of thermocouples, extrusion rate, die pressure, etc. In starting a new operation it is probably best to use a level temperature profile, say 550° F., and adjust from that point.

When starting up an extruder which is full of nylon, it is important to melt the resin in the die first and then melt the polymer in the adapter and barrel. Thus, in case a thermocouple lead is broken or a controller is out of commission, the overheated section will not cause the formation of a "bomb" and a subsequent "blowout" will be avoided.

It is important to maintain the temperature of the adapter, die, and so forth about 5 to 10° F. below the melt temperature. This will prevent overheating of polymer in stagnant areas such as those which exist around a breaker plate or spider, etc., and thus prevent the formation of so-called weld lines.

Types of extrusion

Tubing: Tubing may be extruded using either an in-line (Fig. 2, p. 676) or cross-head (Fig. 3, p. 676) type of die. The in-line die is especially suited when the extrusion is to be carried out horizontally and parallel to the extruder. The cross-head type die is designed for use when extruding vertically downward or horizontally 90° to the axis of the extruder. Tubing is usually fabricated using the horizontal method since vertical downward extrusion is practical only when extruding small diameter tubing (e.g., less than ⅛ in.) and/or when roundness is not important. The high viscosity 6/6 nylon resin (e.g., Zytel 42) is predominately used for tubing extrusion because of the excellent form stability of the molten resin.

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* Polychemicals Dept., E. I. du Pont de Nemours & Co., (Inc.), Wilmington, Del.

[1] Registered Du Pont trademark for nylon resin.

[2] Numbers in parentheses link to References on p. 677.

The tubing die and mandrel are usually designed so that the draw-down ratio[3] is in the region of 3:1 to 6:1. Higher draw-downs cause excessive orientation which may result in longitudinal splitting of the tubing. The following empirical method has been successfully employed in determining the size of the die and mandrel for free extrusion of tubing ½ in. O.D. or less: a) make mandrel 60% larger than the O.D. of the desired tube and b) calculate die diameter using a 4:1 draw-down ratio. It has been found convenient to use the following formulas for determining the size of die and mandrel:

1) $D_M = 1.6\ (OD_T)$

2) $D_F = (6.56\ OD_T^2 - 4\ ID_T^2)^{1/2}$

where D_M = diameter of mandrel; D_F = ID of die; OD_T = OD of tube; and ID_T = ID of tube.

In the extrusion operation, air or nitrogen under regulated pressure is supplied through the mandrel as an internal support for the extruded tube. The pressure with the tubing must be constant to maintain uniform dimensions. The internal pressure may be adjusted somewhat to produce tubing having some variety in diameter and wall thickness from a single die. The size of tubing from a given die is governed by the ratio of take-off speed to extruder output, the air gap, and the internal gas pressure.

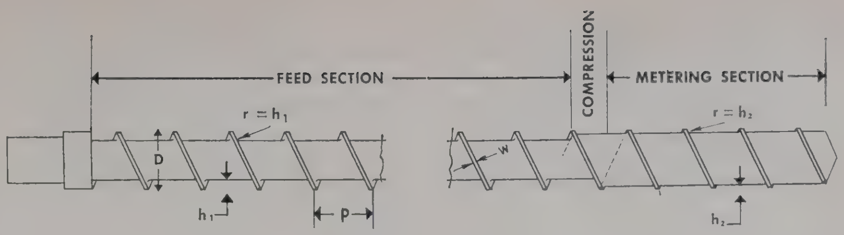

FIG. 1: Screw recommended for extrusion of nylon 6/6 (above) and suggested dimensions (below).

For high-melt-viscosity nylon[1]

Diameter (D)	Pitch (P)	Depth of feed section (h_1)	Depth of metering section (h_2)	Width of land (w)
in.	in.	in.	in.	in.
1½	1½	0.240	0.075	0.150
2	2	0.320	0.085	0.200
2½	2½	0.380	0.095	0.250
3¼	3¼	0.440	0.110	0.325
3½	3½	0.440	0.110	0.350
4½	4½	0.500	0.125	0.450
6	6	0.580	0.145	0.600
For low-melt-viscosity[2]				
1¼	1¼	0.220	0.055	0.125
1½	1½	0.240	0.060	0.150
2	2	0.280	0.070	0.200
2½	2½	0.320	0.080	0.250
3¼	3¼	0.360	0.090	0.325
3½	3½	0.380	0.095	0.350
4½	4½	0.420	0.105	0.450
6	6	0.480	0.120	0.600

[1] Zytel 42
[2] Zytel 101, 31, 63

Nylon tubing can be free-extruded and water quenched in sizes up to and including ⅜ in. O.D. In the neighborhood of ½ in. O.D. it becomes fairly difficult to maintain tubing roundness and therefore other forming methods are preferable. Thus, for producing larger diameter tubing or pipe, a forming-box technique is usually employed.

Shape extrusion: Shape or profile extrusion is best carried out with the higher-viscosity nylon resins because molten polymer has superior strength and form stability. The extrusion of shapes from this resin can be accomplished by either horizontal or vertical downward extrusion into a water quench bath. The vertical extrusion is perhaps the easiest method for controlling the air gap and for maintaining uniform circumferential cooling around the extrudate. It is not recommended, however, for producing shapes which require absolutely straight lengths. The horizontal technique is similar in set-up to that used in the free-extrusion of tubing.

As with other thermoplastics, shape extrusion of nylon is an art and no mathematical description for die design can be given.

Rod can be extruded from either high- or low-viscosity 6/6 nylon. A forming box is usually required for producing rod larger than ⅜ in. in diameter. Smaller diameter rod is most easily free-extruded from the more form-stable, high-viscosity resin.

Bottles: Aerosol or squeeze bottles may be produced by blow molding an extruded tube of high-viscosity 6/6 nylon in conventional bottle blowing equipment. Because the extrusion operation is normally carried out vertically downward, a cross-head tubing die is normally used. It is suggested that a restricted mandrel of the type shown in Fig. 3, p. 676, be employed to insure a uniform circumferential flow of polymer melt through the die annulus. A stock temperature of about 550° F. is normally satisfactory for blow molding of bottles.

The mold temperature is not critical in the blow molding of 6/6 nylon and may range from ca. 40 to 200° F.

Film: High viscosity 6/6 nylon is easily extruded into flat film

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[3] Draw-down ratio is defined as the ratio of the cross-sectional area of the annulus of the die to the cross-sectional area of the extruded tube.

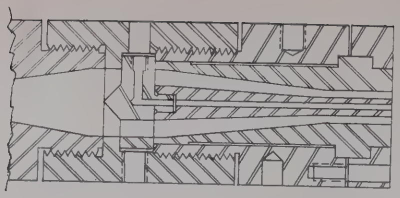


FIG. 2: In-line die for extrusion of 6/6 nylon tubing

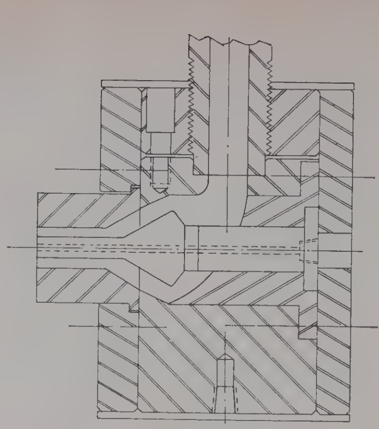


FIG. 3: Cross-head die for extrusion of nylon 6/6 tubing

ranging in thickness down to 0.5 mil. The simplest method is to use a center-fed film die and extrude vertically downward onto a casting roll. The die jaw opening is normally set at 0.010 to 0.015 in. and the casting roll temperature may be about 150° F.

To obtain film of best color it is important to use as low a stock temperature as is practical, maintain a short air gap, and run at high speeds. Tubular or blown film can be made from 6/6 nylon on conventional equipment used for producing film of polyethylene(4). However, tubing made using this process is less transparent and less tough than film which is made on the flat film casting unit.

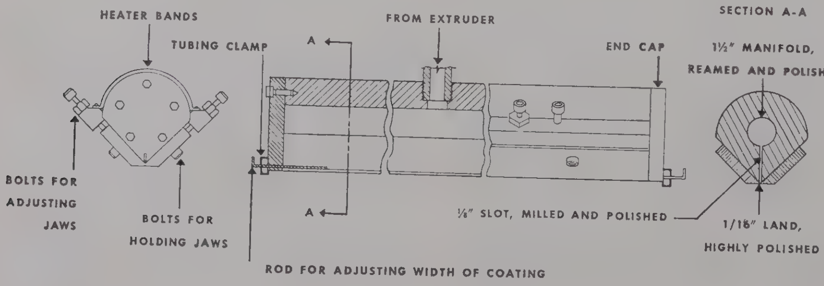
Sheet: Excellent quality sheeting of high viscosity 6/6 nylon may be made using a center-fed sheeting die, a stand of three polishing rolls, and a haul-off unit of two rubber rolls. For preparing exact lengths of sheet it is desirable to have an automatic guillotine cutter—an automatic stacker is also advantageous.

To produce optimum quality sheeting, the extrusion is carried out horizontally with a minimum of air gap, using a fairly low stock temperature (i.e., 550° F.) and as high an extrusion speed as is conveniently possible. The polishing roll temperatures should be about 150 to 200° F. Uniform roll temperature and pressure are essential for producing sheet of uniform thickness.

The die used for sheet or film is shown in Fig. 4, below. The main advantage of this V-shaped die is that the die lips can be brought very close to the nip of the polishing rolls. The die jaw opening is usually set at the desired sheeting thickness. Major caliper variations along the width of the sheet are corrected by making a die adjustment during the run. The finer adjustment in caliper is obtained by changing the temperature in the various zones of the die.

Extrusion coating: Both high and low viscosity 6/6 nylon resins may be used for extrusion coating onto kraft paper and other substrates such as cloth, foil, etc. The advantage of the high viscosity resin is its ease of handling as it comes from the extruder. However, it must be run at higher stock temperatures (ca. 600° F.) in order to obtain a freely flowing melt. The lower viscosity resins lack the melt strength of the more viscous polymers; however, lower temperatures may be utilized in the laminating operation. The die used in extrusion coating should have extended jaws so that the polymer melt is extruded as close to the nip of the rolls (pressure and chill roll) as possible. With this arrangement, most substrates have adequate adhesion to the nylon film in thickness of 1 mil or heavier. The lamination is accomplished in standard equipment used in extrusion coating of substrates with polyethylene(5).

FIG. 4: Type of die recommended for extrusion of nylon 6/6 film and sheet; for extrusion-coating, the die should have extended jaws


HEATER BANDS
TUBING CLAMP
FROM EXTRUDER
SECTION A-A
A
END CAP
1½" MANIFOLD, REAMED AND POLISHED
BOLTS FOR ADJUSTING JAWS
BOLTS FOR HOLDING JAWS
A
⅛" SLOT, MILLED AND POLISHED
1/16" LAND, HIGHLY POLISHED
ROD FOR ADJUSTING WIDTH OF COATING

Use of regrind

A fly knife cutter equipped with a ¼ in. screen is satisfactory for regrinding whole aerosol bottles and shapes such as I-beam or tubing which have been pre-cut to ¼ in. lengths. The feeding characteristics of blends of virgin polymer with up to 50% regrind are similar to virgin material; higher concentrations of regrind should not be used because the nonuniform cut will cause erratic feeding (surging) during extrusion. The amount of regrind which can be used in any specific process will have to be determined by the individual processor. This situation exists because each process will produce scrap material which has a specific thermal history and exposure to moisture and air. Thus, the viscoelastic properties and color of the molten regrind will vary from process to process. Obviously, degraded polymer when used as regrind will cause serious trouble.

If rigid weight and/or thickness specifications are required by a processor it is a good general rule not to use regrind/virgin blends interchangeably with virgin polymer.

Depending upon the process involved, reground material may or may not require drying. Low viscosity 6/6 nylon regrind may be dried in a dehumidified oven whereas the high viscosity nylon must be dried in vacuum at 170° F. for 10 to 20 hours.

Cleaning nylon from extruder

Nylon 6/6 is most easily cleaned from the extruder barrel and screw by running the extruder until dry, removing the die, breaker plate, and screen pack, and then purging the machine with several scoops of acrylic purge compound.[4] During this purging operation the barrel temperatures are not changed. When the purge material is clear from material in the barrel, the extruder is run dry and the screw is removed from the extruder. Usually all that is required is to swab the barrel and clean by wire brushing the screw. The whole operation requires only 15 to 20 minutes. Dies, mandrels, adaptors, etc., are most easily cleaned by placing in a burn-out oven set at 800 to 900° F.

References

For information on sources of commercial nylon materials, consult the Directory Index, on p. 1078.

The following special references, prepared by the author, are referred to within the text.

1) P. N. Richardson, "Streamlining of extrusion dies," SPE J. *14,* 40 (Aug. 1958).

2) Du Pont Polychemicals Dept. Information Bulletin No. X-84A, "Comments on the use of drying ovens." Also, "Predrying of molding powders," by F. I. McCash, MODERN PLASTICS *34,* 120 (Aug. 1957).

3) E. C. Bernhardt, "Stock thermocouples, pressure gauges, and rupture disks for use on plastic extruders," SPE J. *11,* 21 (Nov. 1955).

4) Du Pont Polychemicals Dept. Information Bulletin No. X-70, "'Alathon' polyethylene resin extrusion."

5) Du Pont Polychemicals Dept. Information Bulletin No. X-37e, "'Alathon' polyethylene resin, extrusion coating."

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[4] Suppliers of acrylic purge compound: Cadillac Plastic and Chemical Company, 15111 Second Avenue, Detroit 3, Mich.; Delta Products, Fort Worth, Texas; Wasco Chemical Company, Bay State Road, Cambridge 38, Mass.

EXTRUSION: Wire jacketing nylons

By R. M. Bonner*

In the nylon family are a number of polyamides which have physical properties that make them especially valuable to the wire and cable industry. This discussion will cover particularly the extrusion of 610 resins (Zytel[1] 33) but the processing conditions apply in general to other special-purpose nylons such as Zytel 3606 and 63, which exhibit especially good low-temperature performance. For details on extrusion of 6 and 6/6 nylons, see pp. 674 and 678.

In addition to high mechanical strength and resistance to heat, chemicals, and abrasion, the 610 nylons have the advantage in cable jacketing of absorbing less water than the 6 or the 6/6 nylons, and are used extensively on resistance wire for radiant space-heating systems and on electronic hook-up wire.

Extrusion equipment

Barrel and heating equipment: To attain high extrusion rates, it is desirable to use a long barrel extruder for processing nylon. The L/D ratio should be at least 20:1 but need not be greater than ca. 24:1. Shorter barrel extruders will be more susceptible to problems such as surging and inadequate plastication of the melt.

Because most 610 nylon extrusion operations require barrel temperatures in the range of 500° F., electrical heaters are preferred.

Water cooling of the hopper section is sometimes required in order to prevent bridging of the extrusion granules within the feed section of the screw.

Hopper feed throat: To prevent excessive wedging of the resin particles between the land of the screw and the barrel wall, the direct overhead or tangential-type feed throat should be used.

Screw design: The screw commonly used for processing 610 nylon is a constant pitch, rapid transition (½ turn), with dimensions as suggested in Table I, appearing below.

Screen and breaker plate: If a breaker plate is used, it should be counterbored on the up- and downstream sides to prevent excessive holdup.[2] The screen pack requirement will depend on the specific job being run. A typical screen pack comprises two 120 mesh screens backed up by two 80 mesh screens.

Die design

Tubing dies: Tubing dies are most suitable for applying a jacket of nylon having uniform thickness.[3] With this type of die the thickness of the coating is independent of the geometry of the wire or cable being coated. When such a die is used, a vacuum must ordinarily be applied between the wire and guider tip to pull the flowing cone of molten resin close to the wire.

Two basic tubing die designs are practical for extrusion of 610 nylon.

Adjustable-centering dies give high flexibility of operation, reduce the possibility of introducing weld lines, and cost considerably less than self-centering dies. Self-centering dies, however, are faster

TABLE I: Suggested screw dimensions for 610 nylon[1]

Diameter (D), in.	*Pitch (P), in.*	*Depth of feed section (h_1), in.*	*Depth of metering section (h_3), in.*	*Width of land (w), in.*
1¼	1¼	0.220	0.055	0.125
1½	1½	0.240	0.060	0.150
2	2	0.280	0.070	0.200
2½	2½	0.320	0.080	0.250
3¼	3¼	0.360	0.090	0.325
3½	3½	0.380	0.095	0.350
4½	4½	0.420	0.105	0.450
6	6	0.480	0.120	0.600

[1] See drawing, p. 675.

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*Polychemicals Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

[1] Du Pont trademark.

[2] P. N. Richardson: "Streamlining of Extrusion Dies" SPE J. *14,* (1958).

[3] Du Pont Polychemicals Dept. Bulletin WC-2, "Extrusion for Wire and Cable."

TABLE II: Extrusion temperatures for nylon wire coating

Zytel No.	Barrel Rear °F.	Barrel Center °F.	Barrel Front °F.	Die °F.	Stock °F.
33	500-525	500-525	500-525	500-525	500-525
63	400-475	400-500	400-500	400-500	400-475
69	400-475	400-500	400-500	400-500	400-475
3606	500-550	500-550	500-550	500-550	500-550
37X	525-575	525-575	525-575	525-575	525-575

to set up and get into production than the adjustable-centering type.

Extrusion operation

Drying: The 610 nylon resins absorb moisture from the air at a rapid rate and should contain less than 0.28% moisture when fed to the machine. To insure maximum dryness, containers should be opened at the extruder and the resin poured immediately into the hopper. About one hour's supply should be loaded at one time and then should be nearly exhausted before reloading. It is further recommended that the hopper be covered between loadings. If drying is required, it may be accomplished by using a dehumidified drying oven.[4]

Temperature profile: The temperature of the molten nylon is very important because it influences behavior of polymer in the die and in the finished product. Typical extrusion temperatures used for various wire coating compositions are given in Table II.

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[4] Du Pont Polychemicals Dept. Information Bulletin No. X-84A, "Comments on the Use of Drying Ovens."

EXTRUSION: Nylon 6

By T. R. Von Toerne*

Nylon 6 is a polymer based on the six-carbon-containing molecule, caprolactam (e.g., Plaskon nylons[1]). It has the good qualities usually associated with nylon: high strength, abrasion resistance, solvent resistance, light weight, and self-lubrication. In addition, nylon 6 offers a number of advantages over type 6/6: higher impact strength, low processing temperatures, good dimensional stability, a unique and controllable crystalline structure, and excellent colorability (either during or after extrusion).

The high melt viscosity of certain nylon 6 formulations (e.g., Plaskon nylon 8205) facilitates the extrusion of thick films, tapes, small-diameter rods and tubing, special shapes, and the blow molding of bottles and containers.

Extrusion conditions

Extruder: No large expenditure for specialized equipment is required. Any extruder of sufficient heating capacity to permit continuous operation in the temperature range of 450 to 600°F. is suitable. In general, an electrically heated extruder is preferable. Oil-heated extruders are only marginally adequate, even for low extrusion rates.

The barrel of the extruder should have at least three heating zones, each equipped with a separate temperature controller, to give the desired temperature profile. The overhead hopper feed throat is preferable. An Xaloy 307 liner is recommended for the barrel.

A metering-type screw, of constant pitch, with a 3.5:1 compression taking place over one to three flights, is recommended for the extrusion of nylon 6. Figure 1, p. 679, offers recommended dimensions for this type of screw. S.A.E. 4140 steel or equivalent, with properly hardened flights, is the recommended material for construction of the screw.

Temperatures: Nylon 6 can be extruded over a range of melt temperatures between 450 and 550°F., although a range of 450 to 500°F. is recommended for most extrusion work. The machine temperature should be adjusted to obtain the desired melt temperature at the die; this requires that there be a thermocouple in the melt at that point.

Pressures: The proper melting of nylon 6 requires a sufficient pressure at the discharge end of the screw to insure a uniform homogeneous melt. This pressure depends upon the type of polymer chosen for the application as well as the maximum anticipated throughput requirement. Generally, a pressure of 500 p.s.i. at the lowest throughput will insure satisfactory operation. The building up of this pressure can be accomplished by either: 1) screenpack; 2) die design; or 3) a combination of these two. A pressure gage should be installed at the entrance to the die if possible. Figure 2, p. 679, illustrates one arrangement of a pressure gage in a straight delivery head. The melt thermocouple is also shown.

In cases where no pressure gage is available, screen pack groups as given in Table I, p. 680, should be adequate.

Predrying: Nylon 6 is usually supplied in hermetically sealed containers at a moisture content of less than 0.2%, so that normally it is not necessary to dry the material.

Up to approximately ½ hr. (depending on humidity) after opening the shipping container, the molding powder can still be extruded without predrying. For powders that have exceeded this limit, drying times will range from 3 hr. to as much as 16 hr. at 175°F. A vacuum dryer or dehumidified oven is preferred to a conventional air-circulating oven for drying nylon. If a vented extruder is used, it is possible to omit drying if pellets have absorbed only a slight amount of moisture (less than 0.75%). Pellets with more than 0.75% should be dried.

Nylon 6 scrap can be re-used after drying. Drying time depends on the moisture absorbed.

Die design: Principles of die

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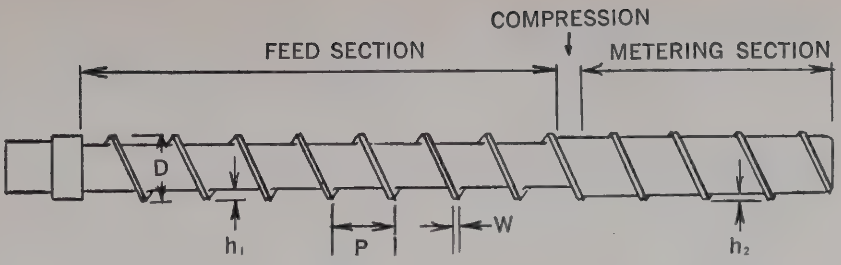
*Shadyside Application Research Laboratory, Plastics and Coal Chemicals Div., Allied Chemical Corp.

[1] Trademark of Allied Chemical Corp.

design that apply to the extrusion of most thermoplastics also apply to the extrusion of nylon 6. All flow through the die should be streamlined. Areas of stagnation should be avoided, since excessive polymer residence time will result in degradation.

Die lands should be long enough to result in a back pressure of at least 500 p.s.i. at the discharge end of the screw. All inner surfaces of the die should be either chrome-plated or constructed of a polished, corrosion-resistant steel.

Figure 2, below, illustrates a typical straight delivery mandrel and die arrangement for extruding tubing.



Dia. (D)	*Pitch (P)*	*Depth of feed section (h_1)*	*Depth of metering section (h_1)*	*Width of land (w)*
in.	*in.*	*in.*	*in.*	*in.*
1¼	1¼	0.260	0.065	0.125
1½	1½	0.280	0.070	0.150
2	2	0.320	0.080	0.200
2½	2½	0.360	0.090	0.250
3¼	3¼	0.400	0.100	0.325
3½	3½	0.400	0.100	0.350
4½	4½	0.440	0.110	0.450
6	6	0.500	0.125	0.600

FIG. 1: Screw dimensions recommended for extrusion of nylon 6

External setup

Cooling: The rate of cooling of a nylon 6 extrusion will significantly affect the properties of the final part.

Essentially, three methods of cooling are used: 1) water bath; 2) air; and 3) contact with cooled surfaces.

Most extrusions can be satisfactorily cooled by tap water. In many cases, however, it is desirable to use a less rapid quench to prevent void formation in heavy sections or to obtain certain desirable properties. All other conditions being equal, quenching in hot water (175°F.) will significantly increase 1) tensile strength, 2) flexural strength, 3) stiffness, and 4) opacity of the extruded part, as compared with a cold-water quench.

Postforming: Because nylon 6 is a crystalline material having a sharp melting point, the postforming fixtures must be located so that forming can be done within the first 3 to 6 in. in the cooling bath. Contoured plates, rollers, or guides are required to guide the extrusion and maintain its desired shape as it solidifies.

Where water cooling is used, it is necessary to maintain a smooth, uniform flow of water at the point where the extrusion enters the water. If this is not done, localized boiling will result which will cause surface imperfections on the extrusion. When cooling extruded tubing, the water level should also be precisely controlled to minimize fluctuations in tubing diameter. This is usually best and most simply done by means of a large adjustable overflow weir at some point along the cooling tank.

Types of extrusion

The extrusion of tubing can be done either vertically or horizontally, although horizontal extrusion is generally the simplest. A water tank 10 to 20 ft. long, the longer length being required for higher extrusion rates, is used for cooling the tubing.

Contoured plates, guides, or rollers are needed to guide and shape the tubing as it is being cooled. A set of motor-driven rolls or belts can be used for pulling the tubing from the extruder die through the cooling

FIG. 2: Nylon extrusion die with provision for thermocouple and pressure gage

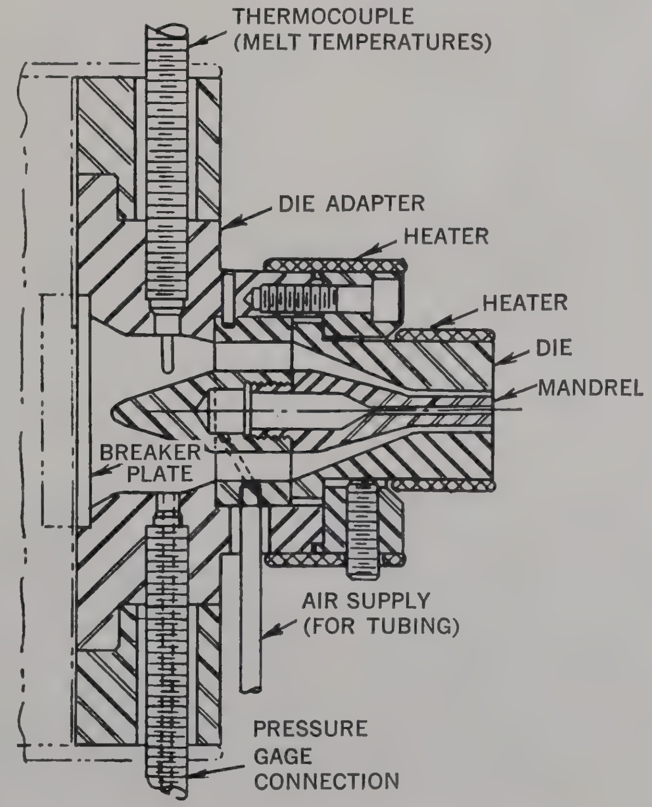


TABLE I: Extrusion of nylon 6

	Monofil.	*Sheeting*	*Wire coating*	*Shapes*	*Pipe*
A) *Machine characteristics*					
Diameter, in., of screw needed to deliver at 60 r.p.m.:[1]					
50 lb./hr.	2¼	2¼	2¼	2¼	2¼
150 lb./hr.	3¼	3¼	3¼	3¼	3¼
500 lb./hr.	5¼	5¼	5¼	5¼	5¼
Recommended L/D	20	20	20	20	20
Recommended screw type	Metering, constant pitch, gradual or sharp compression				
Compression ratio[2]	3.5:1	3.5:1	3.5:1	3.5:1	3.5:1
Depth of feed zone in 150 lb./hr. screw, in.	0.100	0.100	0.100	0.100	0.100
Lead ratio[3]	1:1	1:1	1:1	1:1	1:1
Screen pack, mesh numbers in direction of flow	40, 2-100, 40	40, 2-100, 40	40, 2-100, 40	20, 40, 20	20, 40, 20
Drive power for 150 lb./hr., hp.	30	30	30	30	30
B) *Operating conditions*					
Melt temperature at die, °F.	460	460	485	460	460
Approx. melt pressure at die, p.s.i.	500	500	500	500	500
Screw cooling	Unnecessary	Unnecessary	Unnecessary	Unnecessary	Unnecessary
Is feed preheated?	No	No	No	No	No
Entering temperature, °F.	Room temp.	Room temp.	Room temp.	Room temp.	Room temp.
Metal temperatures, °F.					
Rear cylinder	460	460	485	460	460
Halfway along cylinder	475	475	495	475	475
Forward cylinder	475	475	495	475	475
Die	460	460	485	460	460
Is extrudate water quenched?	Yes	Optional	Yes	Yes	Yes
Water temp., °F.[4]	—	—	—	—	—
Air gap, in.	1.0	1.0	1.0	1.0	2.0
Time in water, sec.[5]	2-10	—	—	—	—
Draw ratio[6]	1.5-4.0	1.5-4.0	1.5-4.0	1.5-4.0	1.5-4.0

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[1] Size to nearest quarter inch. Use next largest standard extruder size when size is not standard.

[2] Compression ratio $= \frac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[3] Lead ratio $= \frac{\text{Distance between corresponding points on successive turns of same flight}}{\text{Inside diameter of barrel}}$

[4] Temp. of water will be determined by properties desired in finished extrusion.

[5] Depends on desired properties, water circulation, dimension of shape. Figure given is approximate.

[6] Draw ratio $= \frac{\text{Cross-sectional area of die opening}}{\text{Cross-sectional area of finished (untrimmed) extrudate}}$

tank. A coiler is recommended for winding the tubing into coils for ease of handling.

The extrusion of small rod, special shapes, and small tape can be handled much the same as tubing. The guide fixtures should be shaped to help form the particular contour being extruded. Large-diameter pipe extrusion will require either a water-cooled, extended mandrel or a vacuum-type calibrating unit to maintain roundness of the pipe. Wide tape and sheet can be made by extruding onto a conventional three-roll polishing stand.

Standard wire-insulating equipment can be used in covering wire with nylon 6. When the latter is used as the primary insulation, it is best to preheat the wire to approximately 325°F. to obtain good adhesion. The preheating can be accomplished with a resistance heater.

The extrusion of nylon 6 film can be accomplished by extruding through a slit die into either a water bath or onto a chill roll.

The chill roll cooling method produces a clearer and smoother film. Nylon film can also be produced by the conventional blowing method from a tubular die. Standard film haul-off and wind-up equipment, with some modification, can be used.

In changing material, the following procedure is recommended: 1) heat machines to 475° F.; 2) when nylon drools from die, start screw and starve-feed new material into throat; 3) use full feeding when nylon emerges from die in steady flow; 4) when extrudate is clear, extruder is ready for running.

The cleaning of the extruder can be simply accomplished by shutting off the hopper supply and running the screw until no more material emerges from the die. The head and dies are disassembled and the nylon removed with a stiff wire brush while the parts are still hot.

As the hot screw is gradually pushed from the cylinder, the molten material is removed with a wire brush. A wire brush mounted on a drill motor is used to clean the cylinder while it is still hot.

The time for the above procedure can be reduced by purging the machine with a few pounds of polystyrene. The polystyrene is more easily removed from machine parts than the nylon.

A small torch can be used for melting or burning the nylon from the tools and extruder parts in the event the nylon has cooled too much to permit removal by wire brushing.

EXTRUSION: ABS polymers

By Eli Schwartz*

The ABS polymers can readily be extruded on all types of extruders, with either single or multiple screws. Their comparative ease of extrudability is due, in large part, to their excellent thermal stability at high temperatures. The versatility in the extrusion conditions and techniques made possible by this stability is an important factor in obtaining high output rates and good appearance. It also allows machine shutdowns to be made for periods of time up to an hour without shutting the heat off. Purging is not necessary with ABS polymers. With some, however, cleaning of the screw is recommended between runs.

If heats are not excessive, ABS polymers may be reworked a number of times, without physical or chemical degradation.

Extruders

Extruder screws from 15:1 through 24:1 L/D ratio can be used with ABS polymers. On shorter barrel machines, compensation for reduced dwell time is made by running at slower rates or by increasing mechanical work in the barrel. A 20:1 L/D machine is recommended for the greatest versatility. Since ABS polymers are high-heat-resistant materials, they remain quite viscous at extrusion temperatures and may require considerable power and proper mechanical drives to extrude at high rates.

Screw design

The design of the screw is extremely important in the extrusion of ABS polymers; different polymers require different screws.

Pipe and tubing: ABS polymers for pipe are divided into two groups, ABS I[1] and ABS II[2], which differ in their degree of impact strength and tensile strength. The ABS I polymers provide extreme toughness with good tensile strength, and ABS II polymers provide extreme tensile strength (with accompanying resistance to creep deformation) at high levels of impact.

The ABS I polymers are softer and require a high-compression, high-work screw to give a smooth product. Compression ratios should range from 3 to 4:1, and flight depths should be shallow (0.090 to 0.150 in.) on the exit end. Full-flighted, constant-pitch, increasing root diameter screws are recommended, although metering types can also be used satisfactorily.

The Type II ABS polymers, being extremely stiff, tend to build up considerable frictional heat. Thus lower work screws are desirable. Compression ratios should range from 2 to 3:1, with flight depths being moderately deep (0.150 to 0.250 in.) on the exit end. Again, the full-flighted, constant-pitch, increasing root diameter screw is recommended. If a metering type is to be used, the change in flight depth at the metering section must not be too severe. An abrupt change at this point will cause a rapid increase in shear stress and a corresponding increase in frictional heat, which can be difficult to control.

For both Type I and Type II ABS polymers, water on the screw is not normally recommended. If only very deep-flighted screws are available, however, an increase in mechanical work can be obtained by putting a small amount of water on the screw. This effectively reduces the depth of flight, increasing the mechanical work, but causing a decrease in extruder output. Fig. 1, p. 682, shows the output *versus* r.p.m. and amperage of ABS Type II polymers with various types of screws.

Sheet: A metering-type screw is recommended for sheet production. The metering section can be in the "pineapple" form of the Dulmage screw or have the abrupt changes associated with the nylon types. High-work screws are necessary because the sheeting die normally provides little back pressure, and heat build-up must be provided by the screw itself. The metering section also provides a constant uniform feed free of screw pulsations. Such a feed is absolutely essential for the highly sensitive gage control process involved in the production of sheet.

Profiles: Screw design for profile extrusion of ABS polymers will be substantially the same as for Type II ABS pipe. The screws here need not provide the degree of plasticization associated with sheet extrusion. Profile cross-sections, themselves, are generally small and normally provide the required back pressure and frictional heat.

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*Technical Service, Naugatuck Chemical Div., U. S. Rubber Co., 1230 Ave. of Americas, N. Y. 20, N. Y.

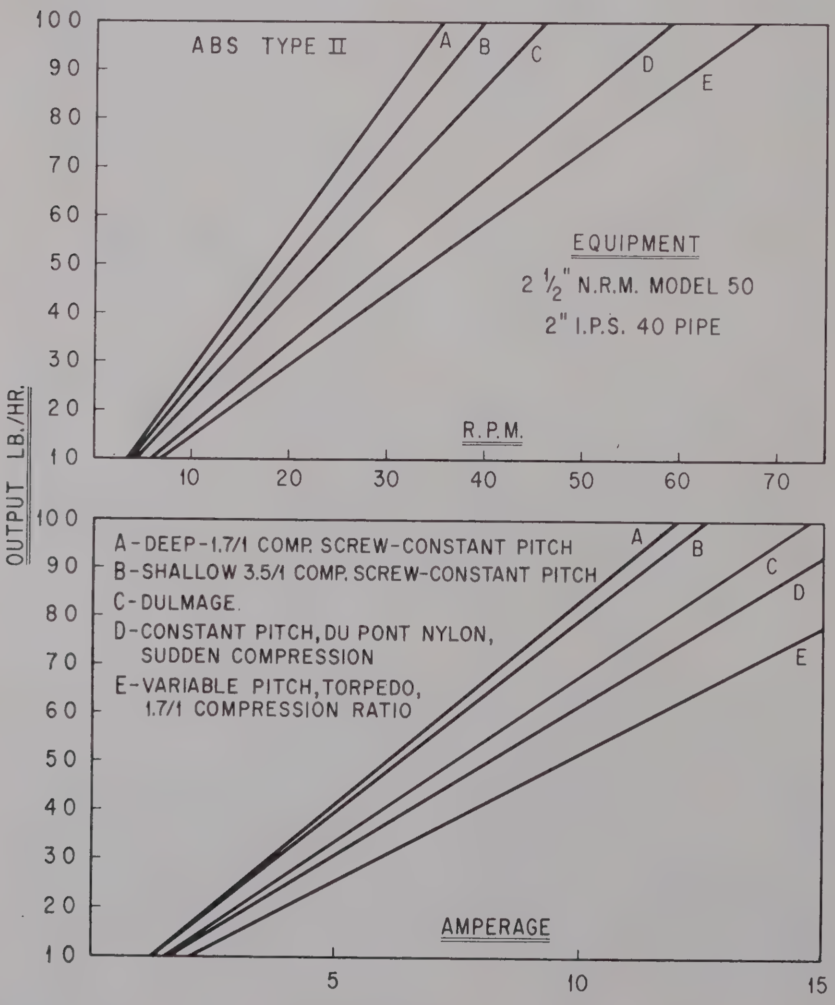
[1] Kralastic B and [2] Kralastic HTHT, products of Naugatuck Chemical Div., U. S. Rubber Co.

Head and die design

Pipe: The same basic die construction can be used for Type I and Type II ABS polymers. Dies should be made of polished, hardened steel and need not be chrome plated. Straight-through die heads are recommended. There seems to be little advantage in using offset and cross-head dies, and they sometimes present unnecessary production problems. Die lands should range from 15 to 30 times the wall thickness. Long-landed dies can be used to advantage if there is a low-work screw in the extruder. The low-work screw provides high outputs, and the long-landed dies provide the necessary work through back pressure. Care must be taken, however, that back pressures are not excessive. Excessive back pressure can easily cause safety pins to shear and head leakage to occur. The dimensions of the die and mandrel depend upon the method of sizing used. Some amount of draw-down will generally be necessary to compensate for the swelling that is obtained at the die orifice. When O.D. sizing techniques are employed, dies should be 5 to 15% oversize, with pin clearance approximating (or slightly larger than) the desired wall thickness. If an I.D. cooling mandrel is employed, draw-down occurs on the wall thickness, and the die opening should be 10 to 20% over the desired wall thickness. The I.D. of the die and the O.D. of the pipe are approximately equal. One spider leg and the mandrel should always be bored and the spider insulated to allow for the introduction of a cooling medium or for the removal of volatiles.

Sheet: Flat sheet dies are considerably more complex than pipe or profile dies. This is because the rate of travel of the plastic mass is faster at the center of the die than at the ends. In order to produce uniform sheet, the pressure gradient at the die orifice must be constant along the whole lip. This uniformity is achieved by allowing a reservoir of material to be accumulated in the die before any substantial amount reaches the lip itself. This reservoir must have sufficient capacity to feed material at a constant rate all along the lips of the die.

FIG. 1: Extruder output vs r.p.m. and amperage with five types of screws



Profiles: Profile dies for ABS polymers should be well streamlined, with land lengths 10 to 15 times the maximum cross-section of the part. Drawdown can range anywhere from 5 to 20 per cent.

Sizing and cooling

Pipe: O.D. sizing is accomplished by the use of sizing rings. The pipe is cooled and set by water cascades or by water immersion. O.D. air rings can be used effectively to facilitate "setting" the pipe as it enters the cooling water, although this is not always necessary. When O.D. sizing methods are employed, I.D. air cooling should be used. The I.D. air cools the die pin and the inside of the pipe.

I.D. sizing is obtained by the use of a water-cooled mandrel. O.D. sizing plates, subsequent to the cooling mandrel, may or may not be used, depending upon the amount of sizing and cooling required. In designing a cooling mandrel, care should be taken to provide for uniform water flow within the cooling mandrel. Heat must be removed from the pipe uniformly. A cooling mandrel should allow for approximately 0.004 to 0.008 in./in. shrinkage.

Regardless of the method of cooling, ABS pipe (and this is particularly true of ABS Type II) should never be shock-cooled. Large amounts of cold water covering the hot O.D. pipe surface induce high thermal stress. This weakens the inherent strength of the pipe and can cause a deterioration in tensile and impact properties. In order to produce low stress Type II ABS pipe, either small amounts of cold water must be used or larger amounts of hot water (140 to 190° F.).

Sheet: From the die, the sheet

TABLE I: Extrusion of ABS polymers

	Sheeting	*Shapes*	*Pipe*	
			Type I	*Type II*
A) *Machine characteristics*				
Diameter, in., of screw needed to deliver at 40 r.p.m.				
150 lb./hr.	3½	3½	3½	3½
175-300 lb./hr.	4½	4½	4½	4½
Recommended L/D	20:1	20:1	20:1	20:1
Recommended screw type	Dulmage	Constant pitch, increasing root diameter		
Exit flight depth, 150 lb./hr. machine, in.		.200	.100	.200
Compression ratio[1]		3:1	4:1	2.5:1
Lead ratio[2]		1:1	1:1	1:1
Screen pack, mesh numbers in direction of flow	40, 20	60, 40, 20	40, 20	40, 20
Drive power for 150 lb./hr., hp.	30	30	30	30
B) *Operating conditions*				
Melt temp. at die, °F.	375-450	390-440	390-440	420-520
Is screw cooled?	Yes	No	No	No
Medium	Water	—	—	—
Temp. of medium, °F.	70	—	—	—
Fraction of length cooled	Feed zone	—	—	—
Is feed preheated?	Yes	Yes	Yes	Yes
Entering temp., °F.	180	180	180	200
Metal temp., °F.				
Rear cylinder	275-350	350-375	350-370	370-400
Halfway along cylinder	325-400	375-400	370-400	380-430
Forward cylinder	350-425	400	400-425	400-460
Die	325-400	375-400	400-450	400-470
Is extrudate water quenched?	No	Yes	Yes	Yes
Water temp., °F.	—	50-80	50-80	See text on cooling of pipe
Time in water, sec.	—	60-300	60-300	″
Draw ratio[3]	—	1.1	1.1	1.05

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[1] Compression ratio $= \frac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[2] Lead ratio $= \frac{\text{Distance between corresponding points on successive turns of same flight}}{\text{Inside diameter of barrel}}$

[3] Draw ratio $= \frac{\text{Cross-sectional area of die opening}}{\text{Cross-sectional area of finished (untrimmed) extrudate}}$

enters polishing or take-off rolls. The temperature of the polishing rolls should run between 170 to 200° F., depending upon the rate of extrusion and the amount of gloss desired. Draw-down of the extruded sheet should be kept to a minimum, since directional orientation can be built into the sheet, causing difficulty in post-forming. Post-forming problems can also be minimized if the extrudate is kept well above its softening point when it is being drawn down or traveling over the embossing rolls. Rubber pull-down rolls, a knife, and stacking unit comprise the remaining take-off equipment.

Profiles: The extrudate must be cooled and sized rapidly, since linear rates are generally very high. Draw-down can vary from 5 to 20%, depending upon the shape extruded. Sizing tools or dies may or may not be used, depending upon the complexity and tolerances of the extruded shape and the linear rate. The pull-down rolls or belt must provide considerable surface contact at an even rate.

Predrying

All ABS polymers must be dried before extrusion. They are normally dried in a hopper dryer, whose capacity should be 2 to 6 times the hourly production rate. Inlet air should be set at 200 to 220° F. Initially, they should be dried for 2 to 3 hours before extruding. Oven or auxiliary drying facilities can be used if sufficient hopper capacity is not available.

Drying times should range from 10 to 12 hours at 160° F. to 2 to 3 hours at 220° F.

Vented extruders can be used as a partial or complete replacement for predrying.

Extrusion temperatures

The most important temperature to be considered in the extrusion of ABS polymers is that of the stock. See Table I, p. 683. Regardless of the polymer used, as a general rule, stock temperatures should be only as high as necessary to obtain optimum physical properties and desired surface appearance. In the case of pipe, where weld or spider lines are present, it is extremely important that stock temperatures (and head temperatures) be sufficiently high so that complete knitting occurs at the weld. When the extruder is run at high r.p.m.'s or when high-work screws are used, considerable frictional heat will build up. Frictional heat, being very uniform in nature, can be used to advantage if it is not allowed to become excessive. It can be controlled, to a large extent, by using air blowers, by shutting off or lowering the external heat, or by reducing back pressure through the use of less screens or less die constriction.

In starting up an extruder, temperatures should be at the lower end of the range and then brought up to the desired temperature. It is important, however, that head temperatures be sufficiently high so that safety bolts do not break and head leakage does not occur. The danger of this occurring is increased when extruder heats have not been on for a sufficient length of time prior to extrusion.

Take-off and cut-off

For pipe and profiles, the pull-down rolls should provide a steady, uniform pull with enough contact area to prevent slippage. It is preferable to be able to control the take-off speed remotely at the extruder. This allows the extruder operator to make rapid changes on the extruder and take-off at the same time.

Cut-off of the extrudate can be done by hand or mechanically, depending upon the type of product and the linear rate.

EXTRUSION: Low-density polyethylene

By E. E. Griesser*

Conditions for extrusion of low-density polyethylene are summarized in Table I. Best results are obtained with a screw (Fig. 1, below) having a constant pitch (equal to diameter), and a gradually decreasing depth from feed section to metering zone.

Polyethylene is widely used in cold water piping for farms, rural homes, lawn sprinkler systems, and wells. Its main advantages are freedom from taste and corrosion and ease of installation. It is sold in standard coil lengths of 50 and 100 ft., with longer lengths made to special order. Sizes above 2 in. cannot be readily coiled. Typical polyethylene pipe extrusion assembly (Fig. 2 p. 686) consists of extruder followed by appropriate pipe sizing facilities, cooling bath, pulling device, and coiling or cut-off equipment. A pulling unit capable of smooth speed variations over a wide range is necessary. Any irregularity in pulling speed will cause waviness in the inner diameter of the pipe.

Several pipe sizing techniques have been employed with favorable results. One technique involves drawing the extruded pipe through a cooling sleeve. This method is not too desirable because the pipe must be kept inflated to be sized and the end plugged to maintain air pressure. A better method is the vacuum cooling sleeve which is used extensively in Europe for sizing polyvinyl chloride pipe. The vacuum holds the pipe against the sleeve, thus eliminating the need for inflating.

The cooling mandrel is another sizing technique used for polyethylene. A dull sand-blasted, water-cooled mandrel is attached to the die pin in a cross head. The material is extruded through the die, and the mandrel sizes the inner diameter of the pipe. For polyethylene, the mandrel should be 6 to 12 in. long and have a 5 to 6% taper to allow for high shrinkage during cooling. The final diameter should be 1 to 2% oversize.

A third method involves the use of sizing plates positioned in a water-cooling trough. The diameter of the extruded pipe can be controlled by properly adjusting the distance between the two sizing plates and by employing the correct sizing hole. This technique calls for specially machined plates having holes through which the pipe is extruded. The first sizing plate contains a hole larger than the desired pipe outer diameter and is placed 6 to 12 in. from the die opening. A second plate similar to the first but usually with a smaller hole is placed 2 to 12 in. behind the first plate. More plates can be used if necessary. For polyethylene, the hole should be 2 to 5% greater than the desired OD in

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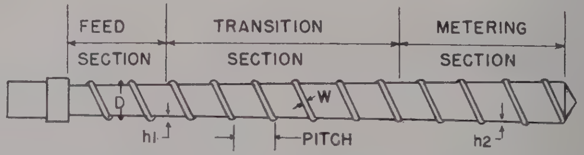
*Development Dept., Union Carbide Plastics Co., Div. of Union Carbide Corp., River Rd., Bound Brook, N. J.

FIG. 1: Constant pitch screw for extruding polyethylene, and suggested dimensions



SUGGESTED DIMENSIONS OF SCREW

Diameter (D), inches	Pitch (P), inches	Channel Depth of Feed Section (h_1), inches	Channel Depth of Metering Section (h_2), inches	Land Width (W), inches	Length L/D
1½	1½	0.240	See Table I	0.150	See Table I
2	2	0.320		0.200	
2½	2½	0.375		0.250	
3¼	3¼	0.375		0.325	
3½	3½	0.375		0.350	
4½	4½	0.425		0.450	
6	6	0.500		0.600	

TABLE I: Extrusion of polyethylene

	Monofil.	*Sheeting*	*Wire coating*	*Pipe & shapes*	*Film (tubular)*	*Film (flat)*	*Coatings, (Paper, etc.)*
A) *Machine characteristics*							
Diameter, in., of screw needed to deliver at 60 r.p.m.							
50 lb./hr.	2-½	2	2	2	2-½	2-½	2-½
150 lb./hr.	3-¼	3-¼	3-¼	3-¼	3-¼	3-¼	3-¼
500 lb./hr.		6	6	6	6	6	6
Recommended L/D	20:1-24:1	20:1	20:1	20:1	20:1	20:1-24:1	24:1
Recommended screw type	Constant pitch, metering, decreasing depth tapering from feed to metering zones						
Compression ratio[1]	4:1	4:1	4:1	3:1	4:1	4:1	4:1
Depth of metering zone for 150 lb./hr. screw, in.	.093	.093	.093	.125	.125	.093	.093
Lead ratio[2] (constant)	1:1	1:1	1:1	1:1	1:1	1:1	1:1
Screen pack, mesh numbers in direction of flow	20/200/100/50/20			20/100/50/20		20/200/100/50/20	
Drive power for 150 lb./hr., hp.	25	25	25	25	25	25	30
B) *Operating conditions*							
Melt temperature at die, °F.	450-500	380-420	390-450	300-375	300-375	400-450	550-600
Approx. melt pressure at die, p.s.i.	1000-3000	500-1500	1500-8000	500-1500	2000-6000	500-1500	500-1000
Screw cooling	Very slight to prevent fouling, especially during start-up						
Medium	Water	Water	Water	Water	Water	Water	Water
Temperature of medium, °F.	100-200	100-200	100-200	70-170	70-170	100-200	150-200
Fraction of length cooled	¼-½	½-Total	½-Total	½-Total	½-Total	¼-½	¼-½
Feed preheating	No	No	Blacks & Colors	Yes (Pipe)	No	No	Desirable
Entering temperature °F.	190 Max.	190 Max.	190 Max.	190 Max.	190 Max.	190 Max.	190 Max.
Metal temperatures, °F.							
Rear cylinder	350	360	350	200	200	300	400
Halfway along cylinder	464	380	440	250	290	350	500
Forward cylinder	482	400	440	290	320	420	600
Die	505	400	440	300	300	400	600
Is extrudate water quenched?	Yes	No (roll)	Yes	Yes	No (air)	Yes	No (roll)
Water temp., °F.	100-200	—	60	60	—	100-170	—
Air gap, in.	3	6	36-120	3-12	6-18 (Frost-line)	1-3	2-6
Time in water, sec.	less than 2	—	10-100	20-100	—	less than 2	—
Draw ratio[3]	1:1	1:1	1:1	1:1 to 1:2	0.020 in. die gap		

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[1] $\text{Compression ratio} = \frac{\text{Volume of thread in first turn past feed opening}}{\text{Volume of thread in last turn at output end}}$

[2] $\text{Lead ratio} = \frac{\text{Distance between corresponding points on successive turns of same flight}}{\text{Inside diameter of barrel}}$

[3] $\text{Draw ratio} = \frac{\text{Cross-sectional area of die opening}}{\text{Cross-sectional area of finished (untrimmed) extrudate}}$

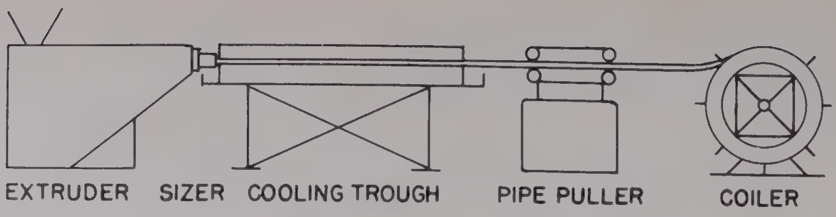


FIG. 2: Schematic of a typical polyethylene pipe extrusion set-up

the first plate and 5 mils greater in the second plate. The amount of drawdown tolerable governs the diameter of the hole.

Each method of sizing pipe has its advantages and disadvantages (see Table II, below). After sizing, the pipe is cooled in a water trough so that strains are minimized and permanent setting is prevented.

Die design

Annular dies with long parallel lands are generally used for the extrusion of polyethylene pipe. In general, the longer the land, the better the pipe surface, but, in practice, the best arrangement will be dictated by proper balance between factors of compound temperature and production rate. A general working rule for design of dies intended for the extrusion of heavy-wall tubing normally considered as pipe is as follows:

Die size	20% greater than aim OD
Pin size	22% greater than aim ID
Die land	Equal to die OD

Temperature control

To extrude polyethylene pipe satisfactorily, good temperature control must be maintained. The temperature of the polyethylene must be sufficiently high as it comes from the extruder to obtain smooth, uniform pipe walls, but not so high as to permit collapse of the extruded section before cooling can take place. Compound temperatures below 300° F. should generally be avoided so that good welding or fusing of any pipe seams, produced by the flow of plastic around obstructions in the head or die in the course of extrusion, will be obtained. Compound temperatures above 350° F. may make it extremely difficult to produce round, uniform pipe and operations are likely to be hampered by sticking at the sizing plate or possibly by collapse of the extruded pipe at the time it enters the cooling bath.

Polyethylene pipe is normally marked by printing the manufacturers name, size, pressure rating, and type on the surface. Imprinting, embossing, and stamping methods which penetrate the pipe surface should be avoided because they can materially weaken the pipe. Rubber or engraved steel transfer printers are most commonly used. The printing inks employed are the same types supplied for marking polyethylene cables.

Polyethylene pipe materials are generally high molecular weight polymers in the 0.2 to 2.0 melt index range and in the low- to medium-density classes. High quality black compounds should be used to prevent degradation of the pipe during outside exposure.

TABLE II: Methods of sizing polyethylene pipe

Method	*Advantages*	*Disadvantages*
Sizing plates	High gloss finish. Very inexpensive.	Small sizes only. Large sizes don't hold roundness or require slight inflation.
Mandrel	Smooth inside surface. Broad size range. One mandrel suitable several OD sizes with same ID.	Start-up difficult. Large sizes require sizing plate to hold roundness.
Cooling sleeve	Smooth, dull finish. Good accuracy.	Requires inflation pressures and plugging of end. High scrap. Sleeve required for every OD size.
Vacuum cooling sleeve	Very accurate. Low scrap rate. Smooth, dull finish.	Sleeve required for every OD size. Most expensive method.

Wire coating

Polyethylene has exceptionally good electrical insulation properties, especially for high frequencies. Consequently, the material has become indispensable for radio, television, radar, and telephone industries as primary insulation. However, it is also used in large volumes as a jacketing material (for line wire and telephone cables) because of its excellent chemical resistance and light stability when pigmented with carbon black. Since polyethylene will burn, it is not used in applications where flammability must be at a minimum.

Wire-coating grades of polyethylene are generally higher in molecular weight than for injection molding and most other types of extrusion, with melt indices usually in the 0.2 to 1.0 range. Special colored compounds available from major suppliers have balanced dielectric properties for multiple pair cables. Wire-coating grades generally contain highly effective anti-oxidants to maintain electrical properties under the oxidizing conditions encountered during fabricating and use. Special black grades are available for long-term outdoor usage, and these must usually be hopper-dried prior to extrusion to remove small traces of moisture normally present.

In the wire coating operation, wire is paid off the unwind reel from a constant tension device, over a preheating device, and into the extruder crosshead (Fig. 3). Preheating of the wire improves adhesion of the coating and helps to remove any residual oil or drawing die lubricant which may be present.

From the preheater, the wire passes into the guider die mounted in the crosshead. The pressure exerted by the screw forces the polyethylene resin over the guider and out of the die. At the same time, wire passes through the guider and emerges coated with a sheath of polyethylene. Wall thicknesses from less than 0.010 in. to greater than 0.500 in. may be applied. The

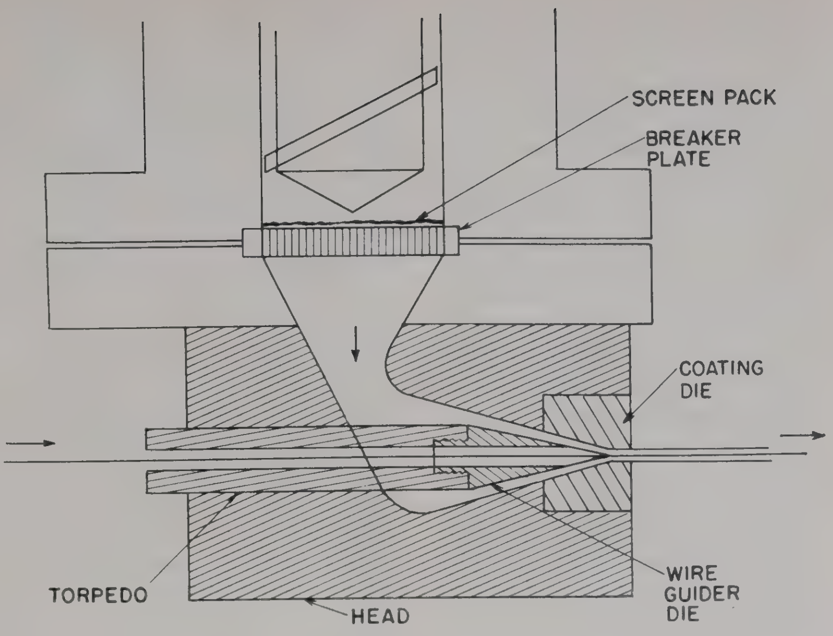


FIG. 3: Extruder cross-head for coating wire with polyethylene

rate at which wire is coated is dependent mainly upon the wall thickness to be applied. Insulations have been extruded on wire at a rate of greater than 2000 ft./min. and on cables about 2 in. diameter at a rate of 30 ft./minute.

Wire coating dies for polyethylene generally have long over-all lands. Dies for small wire coatings have lands in the range of 5 to 20 diameters in length, gradually tapering from entrance to finished size at exit. Cable jacketing dies can be either the direct coating type or tube-on type with parallel lands in the range of 1 to 2 diameters in length.

Monofilaments

Polyethylene monofilaments are used for furniture tape, auto seat covers, rope, and specialty fabrics. Properly oriented, the material is strong and has advantages of light weight, good low temperature flexibility, and excellent resistance to rot, mildew, and fungus.

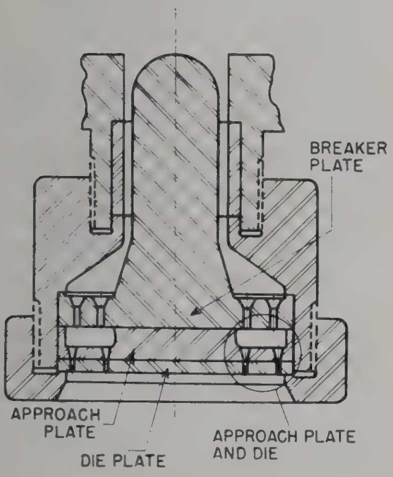


FIG. 4: Multiple-orifice die with streamlined mandrel

In monofilament extrusion, multiple orifice dies (Fig. 4, above) are used with openings arranged in a circular pattern around an internal streamlined mandrel which diverts the material to die openings and avoids a stagnant center portion.

Die design: The die orifice should be approximately equivalent to the diameter of the monofilament before orienting—never larger. If the orifices are larger, the monofilaments must be hot-stretched at the die to attain the desired size. As a result, they may lack sufficient strength to be cold-stretched in the subsequent orientation operation, and frequent breaks may occur.

In the orienting, low- and medium-density resins are generally stretched 600%, high-density resins 800%.

Die sizes and the sizes of fibers oriented 600% which they will produce are as follows:

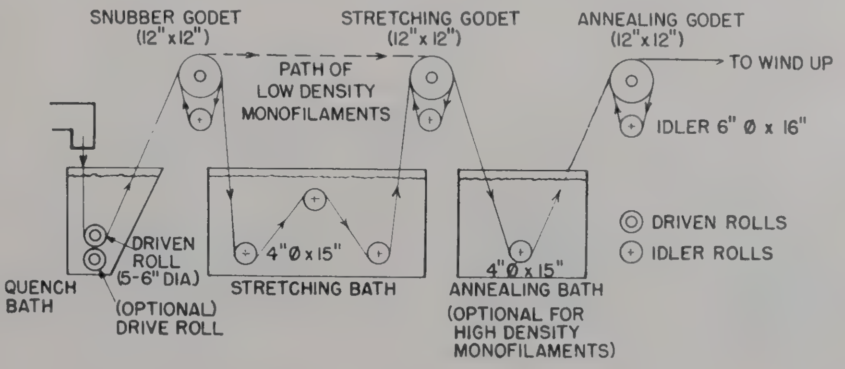
Orifice size	Oriented monofilament size
in.	in.
0.070	0.027
0.060	0.023
0.050	0.019
0.040	0.015
0.030	0.012
0.020	0.008

Stretching and orienting: In a typical stretching and annealing process (Fig. 5, below), the monofilaments are extruded vertically into a quenching bath of room-temperature water. A bath travel of 50 to 60 in. is sufficient to achieve cooling. A freely rotating or driven smooth-face roll at the bottom of the bath will improve the roundness of the fibers. A snubber Godet is used to draw the extruded fibers from the die at a uniform rate. It is not necessary that the Godet rolls be heated, since polyethylene is flexible.

The polyethylene monofilament is stretched by a second Godet operated at seven times the linear speed of the first. Stretching and orientation of low-density monofilaments are carried out in room temperature air. For improved tensile strength, a 575 to 600% stretch is recommended. For maximum tensile strength, the monofilament should be annealed in a water bath under constant tension at temperatures between 85 and 95° C.

Improved high-temperature

FIG. 5: Set-up for stretching and annealing polyethylene monofilaments



shrinkage can be obtained at a sacrifice in tensile strength by passing the monofilament through two annealing water baths at 85 to 95° C. In this procedure, tension should be relaxed approximately 22% in each bath.

For monofilament extrusion, high molecular weight polymers in the 0.2 to 2.0 melt index range and low- to high-density classes are used. Strength and creep properties improve with increasing molecular weight; increasing resin density also has a pronounced effect on increasing strength.

Coating and lamination

Polyethylene coatings can be applied directly to papers, foils, and films to create packaging materials which offer unique property combinations. These coatings are obtained by extrusion through a flat film die and direct application of the molten film against the substrate. Such coatings provide excellent moisture barrier properties and good low-temperature flexibility, and can be readily heat sealed. Also, surface coverage is great, resulting in low cost. Polyethylene-coated products are used principally in the flexible packaging field as food wraps, pouches, milk cartons, and large industrial bags, boxes, and cartons.

The extrusion coating process consists essentially of the following steps: a lineal film is extruded at high temperature into the nip of two rolls (Fig. 6, below), where it contacts the substrate. Pressure is applied by the rolls to achieve lamination. One roll is a water-cooled chill roll which solidifies the polyethylene; the other is a rubber pressure roll.

The process requires a high capacity electrically heated machine, since the resin must be heated to a temperature of 600° F. The extruder die should be located so that the film meets the substrate at the nip of the rolls or slightly to the rubber roll side. If the film should touch the water-cooled chill roll first, unsatisfactory adhesion will result.

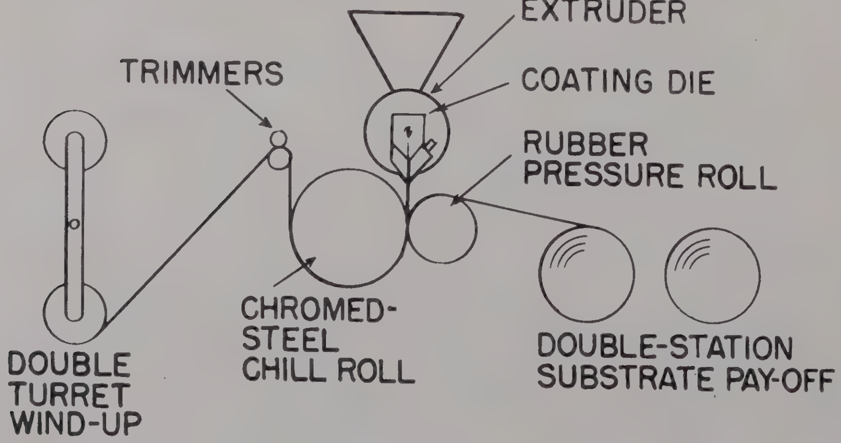
The pressure roll is made of a heat-resistant rubber cured to a Durometer hardness of 70 to 90. The pressure, though not critical, should be in the range of 60 lb./in. along the surface of contact. The chill roll consists of a spirally-cored shell cooled with water so that the surface temperature does not exceed 150° F. Trimmers remove the bead that is formed on each edge and the coated stock is then wound into rolls.

The extrusion coating die is similar to flat film dies except that it must have "V" lips so that the coating is deposited close to the nip.

Extrusion coating equipment is highly specialized, usually consisting of large, long-barreled, electrically heated extruders with heavy-duty wind and unwind equipment. The type of wind-up equipment varies with the substrate being coated, different systems being used for foil, paper, and paperboard.

Polyethylene resins for extrusion coating are usually in the 2 to 8 melt index range and the low- and medium-density classes. The low-density resins are used for general purpose coatings while the higher-density resins provide better grease, oil, and moisture resistance. Coatings as thin as ¼ mil can be applied to paper although coating below ¾ mil are prone to pin holes.

FIG. 6: Steps in coating flexible substrate with extruded polyethylene



Film extrusion

Polyethylene film is the most widely used flexible plastic packaging material and is making progress as a construction, agricultural, and industrial material. Its low toxicity, odorless and tasteless properties, toughness, excellent moisture resistance, easy heat sealing, good low temperature flexibility, and low cost make it ideally suited for these purposes. Principle areas of packaging use include produce, laundry and garment articles, textiles, meat and fish, hardware, and industrial products. Recently, polyethylene film has also penetrated the automatic overwrap field. The material has particularly demonstrated excellent potential for wrapping bread and paper products. Building applications include moisture barriers in walls and concrete work and temporary glazing. Silo covers, crop mulch, greenhouse liners, and tarpaulins are among the film's agricultural uses.

Polyethylene compounds for film extrusion are generally in the low- to medium-density classes with melt indices in the 0.8 to 6 range. Film compounds generally contain special additives such as food grade antioxidants and slip lubricants to control odor, slip, and blocking. Many film properties are related to resin characteristics; for example, clarity and stiffness increase with increasing density, while toughness and tear resistance improve with decreasing melt index and density. In addition, extrusion conditions also affect strength and clarity.

In order to successfully print on polyethylene film, it must first be treated, either electrostatically or by gas flame, to make the surface sufficiently polar to retain inks. The majority of polyethylene packaging film is treated in line with the extruder to minimize further handling.

There are two main methods of extruding polyethylene film: 1) tubular film extrusion and 2) flat film extrusion.

In addition, there are two processes for each method which differ only in the manner of cooling the film. The major process is the blown film or air-cooled tubular film process. Another lesser used process employs a water cooled mandrel to cool the film. The two methods of cooling flat film are water quench and the chill rolls. The advantages and disadvantages of these processes are given in Table III, below.

Blown film

In the blown film process (Fig. 7, right), a tube is extruded from an upright annular die, inflated by air to correct size, cooled with externally blown air, collapsed, and wound on rolls.

In the extruder used for blown tubing, stock temperatures between 300 and 375° F. are typical. The die may be bottom or side fed, but in either case the polyethylene flows around a core pin which forms it into a tube. The die annulus is commonly 0.015 to 0.025 in.; die diameters are 3 to 6 times the extruder diameter. Air is maintained in the tube by the closed die at one end and the motor-driven squeeze rolls at the other.

It is of the utmost importance that caliper be uniform to insure wrinkle-free film and even windup of rolls. The internal air pressure, extruder output, die adjustment, take-off speed, and temperature uniformity are factors which affect caliper.

The amount of inflation or blow-up is defined as the blow-up ratio and is expressed as the ratio of tube diameter to die diameter. Blow-up ratios of 2 to 3 should be used for best results. The frost line or solidification line should be maintained at a uniform height around the tube and normally should be within one to three die diameters above the die lips.

Flat film extrusion

In flat film extrusion, a slot or linear die is used, and the extruded film is drawn into a water quench bath or onto a water-cooled quench roll for the cooling. The cooled film passes through a set of pinch rolls and is then trimmed and wound up. Polyethylene requires compound temperatures in the range of 400 to 450° F. for best results in flat film extrusion.

The die consists of a polished manifold, slotted along its length, and may receive molten resin through either of its ends or through an orifice located midway along its length. A die gap of 0.020 in. is generally used.

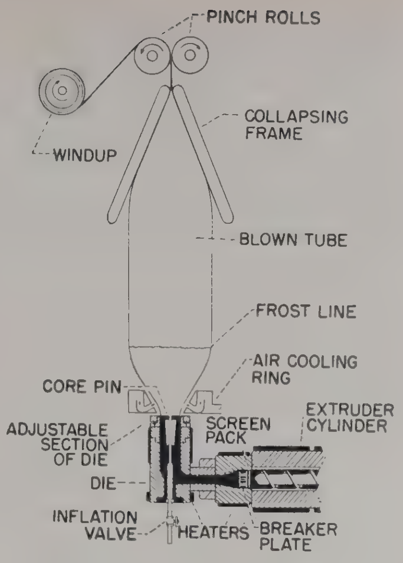


FIG. 7: Blown film process for producing extruded film

As the molten film of polyethylene resin leaves the die opening, it is drawn down into a quench tank in which the water level may be 1 to 5 in. below the die face. It is convenient to have the tank height adjustable so that it can be lowered while changing or cleaning dies. The quench water should be fed to the tank with a minimum of turbulence. To minimize surface ripples and maintain a constant level, the water should overflow the sides of the tank through weirs. In order to obtain uniform properties, the quench bath must be kept at a constant temperature.

The film, after it leaves the die, is drawn into the quench tank, around a polished roller or stationary guide shoe, and out of the tank by means of a pair of pinch-rolls. Speed of pinch-rolls governs the draw-down of the molten film as it travels between die and quench tank, and determines the final caliper of the film.

The trimming operation is per-

TABLE III: Methods of cooling polyethylene film

ADVANTAGES	*DISADVANTAGES*
Tubular Film—Air Cooled	
Wide range of sizes and thickness with one die and air ring. Many grades of resin suitable. Best method for neat rolls. Suitable for tubing or slit sheet film rolls. Balanced properties in machine and transverse directions. Low scrap generation. Low-density resins develop high impact strength.	Does not develop optimum clarity of resin. Air cooling may limit production rate on small sizes.
Tubular Film—Mandrel Cooled	
Accurate diameter control. Better clarity. Suitable for tubing and sheeting. Balanced properties in machine and transverse directions. Positive cooling, higher output.	Mandrel needed for every diameter. Rapid quench makes formulating for slip films difficult. Suitable compounds somewhat limited to medium- and high-density, otherwise too much tack and blocking.
Flat Film—Water Cooled	
Better clarity. Medium-density resins develop good impact strength.	Sheet film only. Unmodified film carries water at high speeds. Slip films tend to carry water even at low speeds. Good rolls require perfect gage. Properties tend to be oriented in machine direction.
Flat Film—Chill Roll Cooled	
Best clarity. No water carry-over problems. Medium-density resins develop good impact strength.	Good rolls require perfect gage. Film has poor slip properties. Rapid quench makes formulating for slip films difficult. Sheet film only. Suitable compounds limited to medium- and high-density range due to blocking.

formed with either a stationary or a rotary-blade unit. Trimming is necessary to remove the edge material which is thicker than the rest of the film. Generally ¼ to ½ in. of the material is removed from each edge during this operation.

Sheet extrusion

Polyethylene sheet (over 0.010 in. thick), extruded on equipment shown schematically in Fig. 8, below, is used for floor mats and runners; for vacuum forming into liners, tote trays, toys, and displays; and in skin packaging.

Polyethylenes in the low- to high-density classes are all suitable for sheet extrusion, and polymers in the 0.2 to 2.0 melt index range are preferred for best extrusion and vacuum forming properties.

Conventional manifold sheet dies are used and compound temperatures in the range of 380 to 420° F. are required for best results. The most critical conditions of polyethylene sheet extrusion are the roll temperatures, especially that of the first roll. This roll must be hot enough to cause complete sticking on contact but cool enough to permit easy release to the second roll. For best results, the temperature must be held within about 5° F. If too cold, pocks and dull spots will occur; if too hot, carrying around the roll will result. The roll temperatures depend on the quantity of heat to be removed in a given time. Heat quantity depends on compound temperature, screw speed, sheet thickness, and other factors; thus proper roll temperatures will vary for different situations. They can be quickly established through trial. It is suggested that the rolls be started cool (150° F.) and heated until pockmarks and dull spots disappear. For the lower-density polyethylenes, this ranges from 160 to 200° F.; for the high-density types, from 180 to 240° F.

Extruder operation

Generally, the extruder should be operated with the intention that the polyethylene be gradually heated, melted and raised to the extrusion temperature, and delivered and maintained at this temperature in the adapter and die. Since laminar flow (without mixing) takes place in the adapter and die, overheating in these parts may cause nonuniform product temperatures which result in variations in viscosity and gage.

Start-up: The following procedure for extruder start-up with polyethylene is recommended whether resin is in the system or not.

a) Turn on all heat controls on the barrel, head, adapter, and die. Set each for 300° F., or standard operating conditions if they are less than 300° F.

b) Permit die, head, and barrel to reach 300° F. temperature on controllers, and hold for 10 to 15 minutes. During this period, turn on all cooling controls on the barrel hopper section, screw, and haul-off equipment.

c) After the waiting period, jog the extruder drive to be sure of no overload, due to solidified resin, then—

d) Operate screw at minimum speed.

e) Raise controller temperatures where necessary to standard operating temperatures.

f) Increase screw speed after standard operation temperatures have been reached.

g) Purge the extruder with resin for ¼ hr. to reach equilibrium, while checking all heating elements for tightness around contact surfaces. Scrape the outside of the die lips with a wood block or brass shim. Any flow lines in the product may indicate dirty lips internally. To remedy this, run a brass shim through the orifice.

h) Continuous operation for several weeks can be expected before a shut-down to clean the die, except for changes of screen packs which should be made at daily intervals. This can be facilitated with a quick-opening clamping arrangement. Of course, if streaks, flow lines, or "fisheyes" persist, an immediate clean-up may be necessary. To minimize down-time, a clean spare die should be kept.

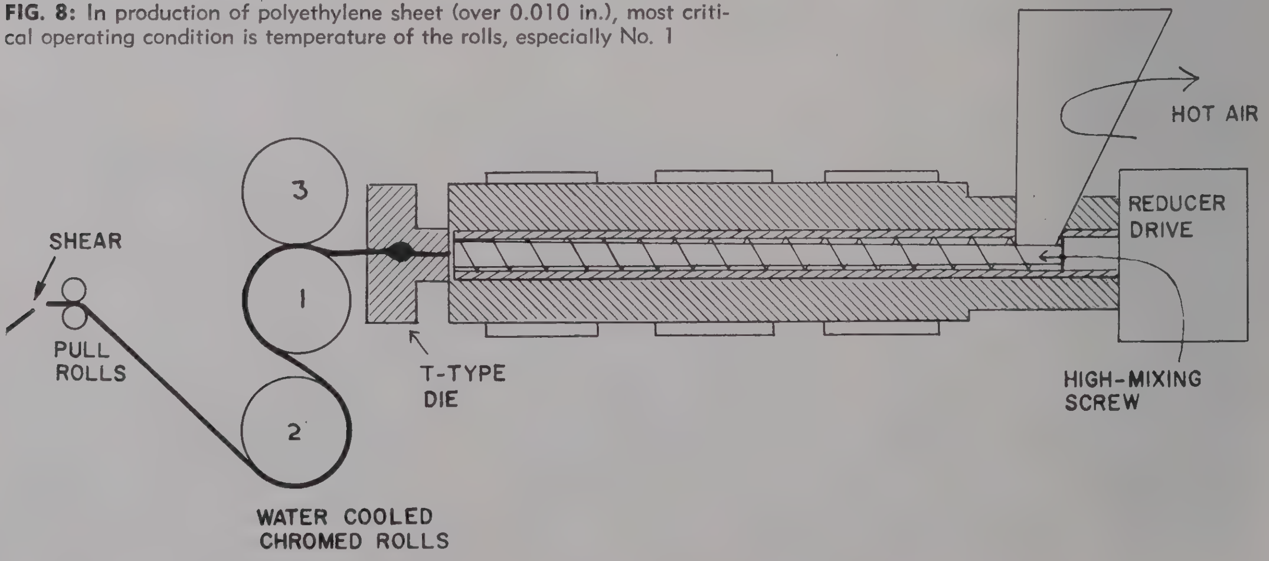
Shut-down: The greatest care should be exercised in shut-down, for it is at this stage that abuse and degradation of resin are likely to occur, especially in film, coating, and monofil operations.

a) Flush a polyethylene purge compound through the extruder and die.

b) Reduce screw to minimum speed.

c) Reduce all heat controls on

FIG. 8: In production of polyethylene sheet (over 0.010 in.), most critical operating condition is temperature of the rolls, especially No. 1



the barrel, head, adapter, and die. Set each for 300° F. or standard operating conditions if they are less than 300° F.

d) Turn on all forced cooling, such as air or water in barrel coils and die.

e) Keep all cooling controls on, particularly the screw temperature control.

f) Purge the extruder with resin until the die temperature (as read on controllers) reaches 300° F. Then stop the extruder screw. Leave the hopper full and cover the die lips with a soft wooden or soft metal strip.

g) Continue cooling to room temperature.

h) No further attention is required. Resin may be left in the barrel and die until the next start-up, unless a complete clean-up is required.

Proper care taken during shutdowns prevents build-up of carbonized compound particles in the die and on the lips. Once carbonized onto the die, these particles can be removed only by a thorough die cleaning or honing.

Clean-out: The great majority of the polyethylene extruded today is of the natural or clear variety. Black, white, and colored compounds are needed, however, for many applications. When switching from a colored to a clear material, or from one color to another, streaking or discoloration caused by any residual compound in the apparatus can be minimized by either 1) a complete clean-out and disassembly of the extruder and die, or 2) flushing out with polyethylene purge compound or a clear resin having a slightly higher molecular weight and a lower compound temperature than the material just extruded. The increased viscosity of the flushing resin provides better push-out. No disassembly is required. When a complete clean-out and disassembly of the extruder and die is required, a polyethylene, vinyl, or styrene purge has been found helpful and time-saving. Several material suppliers now offer special purge compounds which are highly effective.

Other conditions which may dictate a purging or clean-out include: 1) Excessive streaks or web tears at the die. (Introduce purge compound, change no conditions, return to the standard compound.) 2) Changing production from a standard lower melt index material to a standard higher melt index material. (Use purge compound in between to eliminate die lines in high melt index material.) 3) Periodic cleaning for top production efficiency. 4) Shifting production from thicker to thinner gages of film—i.e. under 0.75 mil.

EXTRUSION: Medium-density polyethylene

By J. F. Morris[*] and C. S. Imig[†]

In general, the extrusion characteristics of medium-density (0.926 to 0.940) polyethylene resins are quite good, resembling those of low-density polyethylene (see Table I, p. 685), but requiring slightly higher heats. Both short and long barrel extruders have been used successfully, although the longer barrel machines are preferred.

Pipe extrusion

Great interest has been shown lately in extruding pipe from resins in the medium-density range. This stems from the fact that these resins can be extruded, using conventional techniques, to produce pipe having high burst strengths, high temperature resistance, and easy coilability.

Offset pipe dies or dies having a pin mounted on a streamlined spider can be used with equal success in extruding intermediate-density pipe resins. The offset design is convenient because only one weld is made, as opposed to four welds in the spider arrangement. If the pipe is to be drawn through a sizing tube or over an internally cooled mandrel, the die and pin are usually made 20 to 22% larger than the desired finished dimensions of the pipe. If the pipe is to be sized with an external sleeve and internal pressure, the die is usually made 10 to 15% smaller than the desired finished diameter, leaving about 5% excess in wall thickness to allow for expansion.

The temperature of the melt being extruded from the die must be kept constant and should be high enough to give good surface and adequate welding characteristics; at the same time, it must be low enough that the resin won't be deformed during sizing or become sticky enough to adhere to the sizing apparatus. A melt temperature of 300 to 325° F. is usually found desirable.

Any equipment capable of maintaining constant, positive tension is satisfactory for take-off. The rolls are usually rubber covered to prevent marring of the polished pipe surface. The power take-off is usually built in conjunction with the coiler and cut-off mechanism.

The pipe-sizing techniques used in extruding other polyethylenes have been found to be satisfactory with intermediate-density resins. These usually involve: 1) drawing the extruded pipe through a cooling sleeve and exerting a slight pressure inside the pipe to force the melt against a sizing tube, or drawing a vacuum inside the sizing tube to pull the melt out against the wall of the tube; 2) drawing the hot melt over an internally cooled, tapered mandrel; 3) using a series of sizing plates mounted in the cooling tank with the plates decreasing in size until the desired diameter is reached at the last plate; or 4) using a sizing sleeve which is attached directly to the die and is actually larger so that the pipe is expanded rather than drawn down to match the inside diameter of the sizing sleeve.

The wall thickness can be regulated with any of these methods by simply varying the speed of the power take-off in relation to the output of the extruder.

Film extrusion

One of the most outstanding growth areas for the intermediate-density polyethylenes is in film extrusion. The exceptional clarity and gloss obtainable, coupled with the crispness or stiffness of the film, accounts for this. The film may be made by the blown film process, as flat film extruded into a water bath, or as flat film extruded onto a cooled metal roll. Each of these processes have their own advantages and disadvantages. The vast majority of film produced is by the blown film process but there is considerable growth in flat film extrusion.

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[*] Tech. Service Rep. and [†] Sr. Tech. Service Rep., Spencer Chemical Co., Sales Service Lab., Kansas City, Mo.

Blown film: The familiar process consists of extruding the polyethylene through a tubular die and blowing to the desired size by air pressure inside the tube or bubble. A set of nip rolls retains the air inside the bubble. Film gage is adjusted by balancing the take-off speed with the air pressure inside the bubble. After passing through the nip the film is wound, preferably, on a center wind shaft. When the film is to be treated, an electronic treater is usually placed in line right after the nip rolls. Where flat film is desired from the blown film process, cutting knives are placed right after the nip rolls, both edges cut, and the two sides wound on two separate wind-ups. The extrusion variables affecting the intermediate-density polyethylenes are the same as those affecting low-density polyethylenes.

Intermediate-density polyethylenes offer very good draw-down, allowing thin gage film to be produced. The film exhibits good clarity and it should be pointed out that an apparent maximum clarity for polyethylene film is obtained in the intermediate-density range. Tendency to block is greatly reduced in this density range.

Good film stiffness is obtained along with adequate slip properties in most cases. In some instances, addition of slip additive will be desirable with resins at the lower end of this density range. Generally, a little more care in aligning the take-off and in supporting the bubble is required to insure smooth rolls of good quality film. Various methods such as rotating take-offs, dies, or air rings are also sometimes employed for this purpose. Stock temperatures will vary from 325 to 400° F., depending on the actual melt index and density of the resin being used.

Flat film extruded into a water bath from intermediate-density polyethylenes extrudes in much the same manner as low-density polyethylene. Winding a smooth, wrinkle-free roll is sometimes slightly more difficult. Using higher bath temperatures and reducing the distance from the die lips to the water helps to eliminate wrinkles. As with blown film, draw-down is excellent, making possible smooth operation at thin gages.

A noticeable improvement in resistance to blocking may be seen with intermediate-density polyethylenes. If the proper balance between stock temperature, bath temperature, and distance between die lips and water bath is maintained, the film produced is generally very clear with little haze. Small amounts of slip additive are sometimes desirable at the lower end of this density range but care should be exercised because water carry-over from the bath increases considerably as the amount of slip additive is increased. Treating is normally done right on the take-off unit.

Stock temperatures are in the range of 500 to 575° F., depending on the particular melt index and density resin being used.

A die for flat film extrusion should be designed to lead the material uniformly to the entire length of the die lips. This is done by building a restriction into the die which offers more resistance to flow in the center (where the flow tends to be greater) than at the ends. This eliminates the need for widely different temperatures across the die. Die adjustment bolts and assembly bolts should not protrude down past the bottom of the die lips so that minimum die lip to bath distances may be attained without risking excessive corrosion of the bolts which would hamper adjustment or disassembly of the die. Land lengths should be in the range of ½ to 1 inch.

Flat film extruded onto a cooled metal chill roll displays outstanding clarity and gloss when using intermediate-density polyethylenes. Also, wrinkling does not seem to be as much of a problem as with water bath extrusion. Essentially, the chill roll unit is similar to a water bath unit with the exception that two or more cooled metal rolls are substituted for the water bath. The film is extruded onto the first roll where it sets up initially. The remaining roll or rolls merely serve to remove additional heat before wind-up. Close temperature control is essential on the first roll but is less critical on the remaining rolls.

The same type of die design is recommended for water bath extrusion. However, the die in this case should be tapered to allow minimum distance between the lips and the chill roll.

Stock temperatures generally range from 500 to 575° F., depending on the particular resin being used. The first roll temperature varies from 90 to 160° F., depending on the stock temperature, resin used and speed. This roll temperature is generally run as high as practical, consistent with proper release of the web from this roll. It is often desirable to add some slip additive to resins at the lower end of the range.

Extrusion coating

Permeability and grease resistance improve as the density of a polyethylene increases. A lower coating weight of a higher-density resin can do the job of a higher coating weight of a low density resin.

In extrusion coating, polyethylene is extruded through a tapered flat die into a nip consisting of a rubber roll and a water-cooled metal roll. Air pressure is maintained on the rubber nip roll to give a nip pressure of about 50 to 75 lb./in. along the nip. The cooled roll is maintained at 70 to 140° F.

The substrate passes through the nip between the polyethylene and the rubber roll. Where sandwich constructions are to be made, the polyethylene is extruded into the nip between the two substrates. The substrate is generally preheated to promote better adhesion. At the usual operating temperatures of 550 to 650° F., little difficulty should be encountered with the intermediate-density polyethylenes although greater "neck-in" will probably be encountered.

Wire coating

Usual wire coating apparatus may be used in which the wire is fed from a constant-tension device. The wire is then fed through a preheater which both cleans and heats the wire to improve adhesion. The wire is then passed through a cross-head wire die where the screw of the extruder forces the polyethylene over the leader tip and onto the wire.

In the case of intermediate-density polyethylene, the vacuum draw-down system is rarely used. The push-on type die is used where the polyethylene contacts the copper before leaving the die.

When coating with intermediate-density polyethylenes, it is necessary to cool the insulation rather slowly. To do this, the wire is usually fed into a hot-water bath and then into a cold-water bath.

When it is necessary to clean the extruder and die, it is helpful to reduce the heats to about 350° F. with the machine running very slowly. A plasticized vinyl resin of 85 to 90 Durometer may then be used to purge the extruder and die. On disassembly, the vinyl will easily strip from the metal.

EXTRUSION: High-density polyethylene

By Robert Doyle[*]

Extrusion techniques for the high-density (0.941-0.965) polyethylenes are not yet as firmly established as those for the lower-density types of polyethylene. Thus far, conventional polyethylene equipment and methods have generally been employed. Meanwhile, techniques specifically designed for high-density polyethylenes are being developed and improved. Those operating conditions and procedures which have been found to differ are summarized in the following.

An extruder with a 20:1 L/D ratio is recommended for any extrusion of high-density polyethylene. Also, a stepped-type ("nylon") metering screw is preferred over a stepless metering screw. Screw cooling is usually not required although the hopper should be cooled. Light screen packs (20/80) are generally adequate except for slot-extruded film, extrusion coating, and filaments. For many products, die lands longer than used with low-density polyethylene are also suggested.

Extrusion of pipe

Pipe may be extruded by external sizing tube techniques, using internal air pressure or external vacuum, and by internal sizing mandrel procedures. The use of sizing plates and rings appears to be less preferred at present. Of these techniques, the external sizing tube with internal pressure has received widest acceptance. In this technique, the pipe is extruded about 12% under the final O.D. but with a 5% excess cross-sectional area of material to allow for being blown to size in the sizing tube. The latter tube should be constructed to provide efficient and rapid cooling while also allowing for 2 to 4% shrinkage of the pipe to final size. Extrusion conditions should give a material temperature at the die of 400 to 450° F. for best pipe properties. Thereafter, production rates will depend on the efficiency of cooling in the sizing tube. Additional cooling in a water tank is generally required. The pipe haul-off should provide uniform, good traction on the rigid, glossy pipe thus produced.

Extrusion of filaments

High-density polyethylene has greatly extended the range of properties available in polyethylene filaments. Design of the filament die is very important. The approaches to the orifices must be well streamlined, highly polished, and designed to give a uniform pressure distribution. The orifices must also be highly polished and uniform in size with optically sharp external edges. The land length is not critical. A 1:1 land to diameter ratio is sufficient. The extrudate temperature should be 400 to 600° F.

Contrary to what is done for low-density polyethylene filaments, a 3:1 to 5:1 draw-down in the molten state will give the best final strength. The cooling bath temperature is not critical; tap water is satisfactory. The Godet rolls should be wrapped with a friction cover or sandblasted to provide adequate traction. "Cold" drawing should be done at 175 to 255° F. to give a second draw-down of 5:1 to 10:1 depending on what properties are desired.

For fabrics to be used at elevated temperatures, the filaments should be annealed at a temperature above that to be encountered in actual use.

Film extrusion

Conventional polyethylene film extrusion practices will yield a frosty or milky appearing film with high-density polyethylenes. However, by various quenching techniques, film properties may be varied widely. With the optimum in quick quenching, exceptional clarity and sparkle is achieved. With slow cooling, the maximum impermeability is realized. High-density film is stiff and completely nonblocking. In heavier gages (4 to 20 mils) the blown tubing may be split and thermoformed.

Flat film: Both casting roll and water bath quenching may be used. The cast film is less oriented but the water-quenched film is clearer and more sparkling. Stock temperatures of 525 to 575° F. and a roll temperature of 100 to 150° F. are recommended for the casting roll process. Also suggested are: relatively small die openings, minimum die-to-chill-roll distance, and minimum take-up tension.

In the water bath process, the die should be within about ¼ in. of the water for thin film, the bath should be accurately controlled between 140 to 150° F., and a high-flow (5.0 M.I.) type of high-density polyethylene should be used. A fine screen pack is recommended and a die opening of 0.020 in. may be used for 0.0005- to 0.0015-in. film. Stock temperatures of 425 to 510° F. are indicated with the upper portion of this range being used for the lightest gages.

Blown film: Blown tubing may be extruded from high-density polyethylene with conventional temperatures and equipment provided that the following conditions are observed. Good gage control must be maintained from a clean, adjustable die. Die and pinch rolls must be accurately aligned due to the greater stiffness of the film. If an air ring is used, it must deliver a circumferentially uniform flow of air. Flat plates are preferable to rollers for wrinkle-free flattening of the tube and the included angle between the plates should be small. Also, the high "slip" properties of high-density film dictate the use of center winding rather than surface winding.

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[*] Group Leader, Sales Service Laboratory, Plastics Sales Div., Phillips Chemical Co., Bartlesville, Okla.

References were prepared by the editors.

Sheet extrusion

The sheet dies and polishing roll system used for styrene polymer sheet may be employed for high-density polyethylene with equal success. A three-roll system is preferred over a two-roll system where a good gloss is desired on both sides of the sheet. Die temperatures of 460 to 480° F. are suggested for lighter gages, such as 40 mils, and progressively lower temperatures, down to 320° F., are recommended for heavier gages, i.e., up to 250 mils. A minimum die-to-roll-nip distance is recommended. The polishing rolls may range from 200 to 240° F. with the higher temperature being used for the cooler, i.e., heavier, sheet. Close control of these roll temperatures is important. Tension on the sheet should be held to a minimum consistent with the production of flat sheet. These techniques result in high production rates.

For sheet that is to be thermoformed, a low M.I. (0.2) type of high-density polyethylene should be used.

High-density polyethylenes have been coated onto various substrates at thicknesses down to 2 to 3 mils on standard equipment, but at some sacrifice in running speed. Higher speeds and thinner coatings may be obtained by: a) pressure coating, employing a calendering type of action; and b) blending in of suitable waxes before beginning the extrusion process. The latter offers the broadest general utility, and compounds containing waxes are being developed. Some of these have already been drawn down to coatings of less than 0.3 mils in thickness at speeds exceeding 250 ft./min. while retaining an outstanding degree of impermeability and greaseproofness.

Wire coating

High-density polyethylene wire coating compounds are offered for extrusion at high speeds on standard polyethylene wire coating equipment, at stock temperatures of around 500° F. Preheating of the bare wire is advisable for good adhesion and the coated wire must be cooled slowly to eliminate voids. Four successive baths at 115° F., 190° F., 170° F., and tap water temperature, outward from the die, have been used successfully. Foamed wire-coating compounds from high-density polyethylene, a more recent development, offer considerable promise of further extending the range of electrical properties available.

Purging

In the hot melt condition, a high-density polyethylene strips cleanly off dies and screws more readily than any low- or intermediate-density polyethylene and purging compounds may generally be eliminated.

References

"Extrusion and forming of high-density polyethylene blown tubing," by Robert Doyle, MODERN PLASTICS *35*, 137 (May 1958).

"Extrusion of clear film from high-density polyethylene," by Robert Doyle, SPE J. *14*, 35 (June 1958).

EXTRUSION: Polycarbonate

No serious problems are presented in the screw extrusion of polycarbonate (PC) resin (Lexan[1]). Its low flow-sensitivity to pressure-difference and temperature makes it better behaved, from the extrusion standpoint, than many other resins whose working temperature ranges are narrower, or whose flow is more sharply affected by changes in temperature and back-pressure in the extruder.

The same precautions concerning moisture must be observed in extruding this resin as in injection-molding it—minimum exposure to room air, preheating cans before opening them, and using a dehumidifying hopper-drier if it is available.

On the basis of experience to date, all conventional screw designs seem to perform equally well with PC, delivering about the same quantity and uniformity of output. Bridging of the feed occasionally occurs and may be avoided by starve-feeding the screw during start-up until extrudate begins to appear, then filling the feed hopper. Vented cylinders are not necessary.

Because PC remains relatively viscous at high temperatures and high extruder-head pressures, pressure back-flow is apt to be lower, and output higher than usual for a given screw speed. High screw speeds may develop excessive pressures and overload the motor, especially if melt temperatures are low. Normal operating pressures range from 500 to 3000 p.s.i., depending on the product and die geometry.

Barrel temperatures in the range 525 to 575° F. are satisfactory. Temperature profile is usually uniform, although the die may be run up to 20° hotter than the cylinder and the feed zone as low as 20 to 50° F. cooler. Neither the screw nor the feed throat need be closed. However, where viscous working is heavy, the barrel may have to be cooled.

PC extrudates may be cooled with air or water, depending on their shapes. Too rapid cooling of thick sections may cause internal voids due to shrinkage.

Either blown or flat film can be made from PC. However, it may be difficult to collapse and wind a blown tube without wrinkling it, so blown-film extrusion is not now recommended. Draw ratio should be about 2 to 2.5 for films thicker than 10 mils. For thicknesses under 10 mils, a die-lip opening of 20 to 25 mils is suggested, with appropriate drawdown. It is recommended that flat film be extruded directly onto take-up rolls held at some temperature between 200 and 250° F.

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[1] Trademark of General Electric Co.

EXTRUSION: Polypropylene

By Dr. F. Ranalli* and Dr. G. Crespi*

Polypropylene can be processed by the extrusion technique using conventional equipment without any particular difficulty. Extrusion temperatures vary in the range between 370 and 520° F., according to the grade of polypropylene which is being employed for extrusion.

Single-screw or twin-screw extruders may be successfully employed. Screws having a high length-to-diameter ratio (L/D=17 to 20) and a compression ratio from 2 to 4 are preferred.

Temperature: The temperature of the extruder barrel should increase progressively from the hopper to the head. At the head, the temperature should be slightly reduced. In some cases, such as large straight-head extruders for film, it may be necessary to increase the temperature of the head to some extent.

Extrusion of pipe

By way of comparison, we assume that in a standard extruder the working temperatures from hopper to nozzle for PVC would be as follows: 320-340-340-320° F. Polypropylene can be extruded in standard equipment for extruding pipe in a temperture range between 320-375-390-375° F. (from hopper to nozzle) and 320-430-465-430° F. (from hopper to nozzle.)

The above temperatures are suggested as the average working range for the extrusion of polypropylene pipe.

External calibration and drawing: Calibration is easily obtained by means of the common vacuum or pressure forming boxes used for PVC and low-density polyethylene. These pressure forming boxes usually have a diameter 15 to 20% greater than the diameter of the die.

The pipe can be cooled after extrusion with cold running water within a 6-ft. length from the sizing die outlet.

The drawing system can be selected from among those commonly used for PVC or polyethylene pipes.

Extrusion of film

Polypropylene is a polymer which can be extruded either as tubular blown films or as flat film with standard equipment employed in processing polyethylene.

The working temperature can vary in a wide range depending on the fluidity of the polymer used and on the type of extruder. Temperatures between 370 and 480° F. are preferred, maintaining the temperature of the die 50 to 70° F. below that of the barrel.

When polypropylene film is quenched in a water bath at a temperature below 80° F., a soft, tough, and very transparent film is obtained which is expected to have unique applications in the packaging field. It is necessary, however, that the film enter the water bath no more than ¼ in. from the extruding die. The film thus obtained can be oriented by mechanical stretching, similar to the methods used for orienting other thermoplastics.

This treatment, which causes an orientation of the polypropylene crystallites, gives the film an extremely high tensile strength parallel to the direction of stretching which is at least 4 times greater than the original tensile strength.

Extrusion of sheet

Polypropylene can be easily extruded in flat sheets with the same equipment used for extruding high-impact styrene or polyethylene.

The feeding of pelletized material to the extruder does not require special handling; nevertheless, it is advisable to regulate continuous feed by means of a vibrator or other suitable device. It is also preferable to equip the hopper with a predrying device to eliminate small amounts of surface condensation which may accumulate during storage or transportation. The extrusion temperatures usually vary between 375-410-450-430° F. and 375-450-500-465° F. from hopper to nozzle, depending on the thickness of the sheet and the type of extruder used.

Wire and cable covering

Polypropylene is suitable for covering cables and wires by continuous extrusion around the metallic core, according to standard processing methods. Rather high temperatures are advisable (up to 520 to 540° F.), as measured on the material in order to obtain a high hourly output.

Difficulties which could arise in uniformity of thickness and appearance of the covering can be eliminated by suitably modifying the shape of the extruding nozzle (high length to thickness ratios of 10:1 to 40:1 are preferred) and by varying the extrusion temperature, the screw speed, and the screens in the nozzle.

As a general rule, and particularly in the case of cables having a polypropylene covering thicker than 0.04 in., it is advisable to cool the extruded cable in several stages with a thermal gradient of the cooling water from 205° F. next to the nozzle, down to 80° F. in the last cooling vessel.

By following this procedure, the formation of voids inside the covering due to radial nonhomogenous shrinkage of the polypropylene layer can be avoided.

Extrusion of monofilament

Polypropylene can be extruded as monofilament which, after stretching at temperatures lower than 320° F., possesses a tensile strength which is many times higher than that of the original monofilament.

In some orientation tests, tensile strengths have been obtained in the order of 65,000 p.s.i. Stretching ratios up to 8:1 are possible. Test conditions used in a group of experiments are reported.

A 1.2 in. extruder with a vertical head and die having 20 holes of 22 mils dia. each was used. Temperatures were as follows: barrel—450 to 480° F.; head—450° F.; die—380° F.; cooling water—160° F.; hot air oven—225 to 250° F.

The periphery speed of the take-off rolls was about 40 ft./min. and periphery speed of the stretching rolls was about 325 ft./minute.

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*Montecatini Soc. Gen., Via Turati 18, Milano, Italy.

Data presented in this article were obtained with Montecatini's Moplen polypropylene.

Check list of defects and causes in:

Extruded plastics parts

ABS POLYMERS

Defect: Lumpy or nervy product
Possible causes
- ☐ Barrel temperatures too low
- ☐ Insufficient screen pack
- ☐ Too low-work screw
- ☐ Too high output

Defect: Voids or bubbles on surface
Possible causes
- ☐ Insufficient drying
- ☐ Stock temperature too high
- ☐ Head or die temperature too high

Defect: Surging or nonuniform dimensions
Possible causes
- ☐ Improper screw
- ☐ Stock temperatures too cold
- ☐ Head temperatures too cold
- ☐ Improper spacing of sizing plates
- ☐ Uneven pull-off

Defect: Poor weld line strength
Possible causes
- ☐ Stock temperatures too low
- ☐ Head temperatures too low
- ☐ Cooling of spider legs

Defect: Brittleness
Possible causes
- ☐ Stock temperatures too low
- ☐ Stock temperatures too high
- ☐ High thermal or mechanical stress

Defect: Low extrusion rates
Possible causes
- ☐ Improper screw
- ☐ Screen pack too high
- ☐ Die lands too long

Defect: Excessive heat build-up
Possible causes
- ☐ Work screw too high
- ☐ Too much restriction in head or die
- ☐ Screw speed too high

Defect: High thermal stress product
Possible causes
- ☐ Insufficient I. D. cooling
- ☐ Shock cooling on pipe O.D.

CELLULOSICS

Defect: Discoloration
Possible causes
- ☐ Compound temperature too high
- ☐ Mechanical work done by screw too severe
- ☐ Too much scrap being recycled
- ☐ Stagnation areas in either screw, gate, or die

Defect: Die lines
Possible causes
- ☐ Overheated die blades cause excessive sticking of cellulosics polymers to steel
- ☐ Carbonized material in back of the die blade or in non-streamlined sections
- ☐ Nicks or defects in the die

Defect: Discontinuous lines
Possible causes
- ☐ Extrudate not dry
- ☐ Extrudate temperature too high

Defect: Drip marks
Possible causes
- ☐ Plasticizer will condense on overhanging die parts and drip on product
- ☐ Leaking between die sections

Defect: Holes, blisters, flow bands
Possible causes
- ☐ Poor seals between the die and gate, or gate and extruder
- ☐ Breakdown of compound in areas of poor seal or poor streamlining
- ☐ Nicks, scratches or other surface defects restricting melt flow in small sections
- ☐ Extrudate temperature too high

Defect: Frosted surface
Possible causes
- ☐ Low die heat

Defect: Surging
Possible causes
- ☐ Poor screw design
- ☐ Variation due to malfunctioning instrumentation
- ☐ Screw wear
- ☐ Variation in pellet feed
- ☐ Variation in extrudate being recycled or large percentages of recycle

Defect: Cross-lines
Possible causes
- ☐ Take-off chattering
- ☐ In sheet or film cast onto a hot roll, lines may be causes by hard stripping

Defect: Pit marks
Possible causes
- ☐ Localized contractions on contact with a cool surface of the take-off

Defect: Smudge
Possible causes
- ☐ Condensation of plasticizer on the take-off supports
- ☐ Bending and unbending of the extrudate

NYLON 610

Defect: Frothing of extrudate
Possible causes
- ☐ Excessive moisture in resin
- ☐ Stock temperature too high at some point
- ☐ Hold up in equipment (poor streamlining)
- ☐ Hot spot due to faulty thermocouple (e.g., poorly located, broken, etc.)

Defect: Roughness—aircraft hook-up wire jacket, etc.
Possible causes
- ☐ Roughness of base wire
- ☐ Melt temperature too low
- ☐ Insufficient vacuum
- ☐ High drawdown (in excess of 8:1 based on cross-sectional area)

Defect: Poor adhesion of nylon jacket
Possible causes
- ☐ Drawdown ratio too high (in excess of 8:1)
- ☐ Insufficient vacuum

Defect: Longitudinal splits in finished jacket
Possible causes
- ☐ Moisture or dirt on base wire
- ☐ Excessive moisture in resin
- ☐ Drawdown ratio in excess of 8:1
- ☐ Insufficient vacuum
- ☐ Die design—insufficient welding
- ☐ Extrusion temperature too low

Defect: Erratic feeding (surging)
Possible causes
- ☐ Rear barrel temperature too cold
- ☐ Poor screw design (no metering section, channel too deep)
- ☐ Belt slippage in extruder drive
- ☐ Undercut feed section

Defect: Pimples or bumps on surface of coating
Possible causes
- ☐ Roughness of base material
- ☐ Moisture in base material
- ☐ Cross contamination of resin
- ☐ Insufficient plastication of melt: a) Extruder barrel too short; b) Poor screw design; c) Insufficient screen pack

Defect: High power requirement of extruder (high amperage)
Possible causes
- ☐ Improper screw design: a) Solid nylon particles are wedged between the land of the screw and the barrel wall—avoid the use of an undercut feed throat; b) Too deep a feed and/or metering section. Solid particles conveyed all the way to the screen pack cause plugging
- ☐ Barrel temperature too low
- ☐ Degraded material on the land of the screw after too many start-ups and shut-downs with polymer in the barrel

POLYETHYLENE

P/E FILM

Defect: Weak strength

Possible causes

- ☐ Thin spot in film as extruded
- ☐ Excessive temperature and pressure in nip
- ☐ Cold compound
- ☐ Unequal orientation, excessive shrinkage in one direction

Defect: Poor clarity

Possible causes

- ☐ Cold compound
- ☐ Poor cooling
- ☐ Wrong type compound

Defect: Wrinkles

Possible causes

- ☐ Improper alignment of haul-off gear with die
- ☐ Nonuniform bubble geometry, unequal cooling
- ☐ Dragging or sticking to collapsing frame or rolls
- ☐ Excessive caliper variation from die or cooling
- ☐ Insufficient cooling

Defect: Streaks or lines in film

Possible causes

- ☐ Dirty die lips
- ☐ Weld or spider lines
- ☐ Material hold-up in die portions
- ☐ Scratches from wind-up
- ☐ Poor mixing in extruder

Defect: Wide variation of film gage

Possible causes

- ☐ Nonuniform temperature or flow from die lips
- ☐ Nonuniform cooling across or around web

P/E PIPE AND SHAPES

Defect: Lines in machine direction

Possible causes

- ☐ Hold-up in die portions
- ☐ Dirty die lips
- ☐ Weld lines

Defect: Roughness

Possible causes

- ☐ Fisheyes or contamination
- ☐ Water pock marks
- ☐ Air bubble pock marks
- ☐ Cold compound
- ☐ Moisture
- ☐ Sticking to sizer
- ☐ Die too hot or too cold

Defect: Weak strength

Possible causes

- ☐ Low compound temperature
- ☐ Weak weld lines
- ☐ Low wall thickness or thin spots

Defect: Varying diameter

Possible causes

- ☐ Material surging
- ☐ Uneven take-off speed
- ☐ Sticking to sizer

P/E WIRE AND CABLE

Defect: Roughness

Possible causes

- ☐ Cold compound temperature
- ☐ Poor mixing
- ☐ Moisture
- ☐ Fisheyes, contamination
- ☐ Poor die design, or cold die

Defect: Voids, bubbles

Possible causes

- ☐ Air entrapment by screw
- ☐ Moisture
- ☐ Contraction voids from too rapid chilling

Defect: Low mechanical strength

Possible causes

- ☐ Compound too cold
- ☐ Insufficient conductor preheat

Defect: Low electrical properties

Possible causes

- ☐ Contamination
- ☐ Poor colorants

P/E SHEET

Defect: Lines in machine direction

Possible causes

- ☐ Dirty die lips or stagnation in die or head
- ☐ Scratched rolls

Defect: Roughness

Possible causes

- ☐ Cold compound
- ☐ Poor mixing, screw channel too deep
- ☐ Moisture in material

Defect: Excessive caliper variation

Possible causes

- ☐ Material surging
- ☐ Poor die adjustment, or die not clean
- ☐ Variation in haul-off speed

Defect: Surface blemishes

Possible causes

- ☐ Moisture in material
- ☐ Sticking to rolls
- ☐ Rolls too cold

P/E EXTRUSION COATINGS

Defect: Insufficient adhesion

Possible causes

- ☐ Low material temperature, leaving die
- ☐ Excessive draw distance
- ☐ Coating precooled by air drafts or by sticking to chill roll before reaching substrate
- ☐ Presence of excessive size, lacquer or oil on substrate

Defect: Excessive caliper variation

Possible causes

- ☐ Material surging due to screw-speed variation or screw fouling
- ☐ Nonuniform die caliper
- ☐ Material drawing nonuniform from die, material temperature varying

P/E MONOFILAMENTS

Defect: Excessive strand breakage

Possible causes

- ☐ Compound too cold
- ☐ Material or screw surging causing strand variation
- ☐ Excessive orientation for the material
- ☐ Contamination
- ☐ Nonuniform strand temperature during orienting
- ☐ Uneven orienting speed

Defect: Low strength

Possible causes

- ☐ Insufficient orientation
- ☐ Strands oriented too hot
- ☐ Insufficient annealing

POLYPROPYLENE

Defect: Pulsation of extrudate

Possible causes

- ☐ Inadequate L/D ratio, less than 16/1
- ☐ Too low cylinder temperature profile
- ☐ Erratic feed and feed temperature, bridging
- ☐ Screw temperature too high
- ☐ Inadequate screw compression, less than 4/1
- ☐ Too short land area, less than 20 or 30 to 1
- ☐ Nonstreamlined flow in throat or die
- ☐ Insufficient screen pack

Defect: Poor surface

Possible causes

- ☐ Surface moisture on pellets or reground
- ☐ Short land length
- ☐ Low stock temperature
- ☐ Improper screw design
- ☐ Water marking

Defect: Poor toughness

Possible causes

- ☐ Low stock temperature
- ☐ Unbalanced orientation

PTFE TUBES

Defect: Folds or flaps in tube wall structure

Possible causes

- ☐ Powder sheared, over-worked
- ☐ Flash toward ram or between die and cylinder wall

Defect: Blistering

Possible causes

- ☐ Too high drying temperature
- ☐ Entrapped moisture
- ☐ Entrapped air

Defect: Partial internal splits

Possible causes

- ☐ Insufficient deformation at mandrel
- ☐ Temperature gradient across extruded tube cross-section

Defect: Out of round

Possible causes

- ☐ Too much tension during drying and sintering
- ☐ Uneven quenching

Defect: Scarred surface

Possible causes

- ☐ Dry spot in billet
- ☐ Extruding below 66° F. transition temperature
- ☐ High shearing of billet due to insufficient naphtha

- ☐ Billets stored too long, causing loss of naphtha
- ☐ Scratches or pits in die, cylinder, or mandrel

Defect: Dark grey color

Possible causes

- ☐ Tubing overheated during sintering

Defect: Excessive fibering

Possible causes

- ☐ High shearing of billet due to insufficient naphtha
- ☐ Billets stored too long, causing loss of naphtha
- ☐ Scratches or pits in die, cylinder, or mandrel

Defect: Heavy dark or black splotches or streaks

Possible causes

- ☐ Carbon residues due to grease and oil
- ☐ Airborne lint or flecks from cotton gloves

Defect: Curling to one side and irregular flow, including rippled extrudate

Possible causes

- ☐ Uneven density in the preform
- ☐ Partial evaporation of naphtha on one side of preform
- ☐ Faulty centering at start of extrusion
- ☐ Faulty alignment of extrusion cylinder

Defect: Uneven wall thickness

Possible causes

- ☐ Faulty centering at start of extrusion

Defect: Longitudinal splits

Possible causes

- ☐ High shearing of billet due to insufficient naphtha
- ☐ Billets stored too long, causing loss of naphtha
- ☐ Hang-up of hard particles in die
- ☐ Too high drying temperature
- ☐ With small tubing (to ½ in. I.D.), excessive flexing
- ☐ With larger tubing (1 in. I.D. and up), too much lateral movement in drying oven

Defect: Wavy, broken surface

Possible causes

- ☐ Overworking powder before compounding

FLEXIBLE PVC

Defect: Surface roughness

Possible causes

- ☐ Stock too cold
- ☐ Insufficient work
- ☐ Tip too close to die
- ☐ Cold die (dull)
- ☐ Rate too high

Defect: Porosity

Possible causes

- ☐ Overheated compound
- ☐ Trapped air or volatiles
- ☐ Low-compression screw (powder)
- ☐ Compound not fluxing far enough back in machine

Defect: Excessive strains

Possible causes

- ☐ Drawdown at too low a temperature
- ☐ Too much drawdown
- ☐ Cold conductor with thin wall
- ☐ Coolant at too low a temperature

Defect: Black specks, dark streaks

Possible causes

- ☐ Overheated compound
- ☐ Material caught in dead spot gradually flaking off
- ☐ Material stuck to screw and burned
- ☐ Contamination

Defect: Surging

Possible causes

- ☐ Improper feeding in hopper
- ☐ Insufficient back pressure
- ☐ Inadequate screw cooling
- ☐ Tip too close to die

FEP RESIN WIRE COATING

Defect: Surface roughness

Possible causes

- ☐ Die temperature too low
- ☐ Melt temperature too low
- ☐ Resin velocity in die too high
- ☐ Improper die design
- ☐ Rough die surfaces

Defect: Coating not centered or not round

Possible causes

- ☐ Die not centered
- ☐ Wire floating on quench water or contact with water not being made uniformly (uneven shrinkage)
- ☐ Hot wire dragging over metal surfaces
- ☐ Improper die design
- ☐ Air gap too short

Defect: Poor adhesion

Possible causes

- ☐ Insufficient vacuum
- ☐ Improper die design
- ☐ Contamination on wire
- ☐ Improper cooling

Defect: Pinholes, splits

Possible causes

- ☐ Contaminated resin
- ☐ Too high draw ratio
- ☐ Stock temperature too low
- ☐ Contamination on wire or primary coating

Defect: Caliper variations

Possible causes

- ☐ Stock temperature fluctuations
- ☐ Variation in speed of capstan or slippage of capstan
- ☐ Variation in extruder output
- ☐ Incorrect screw
- ☐ Insufficient vacuum
- ☐ Uneven wire payout

Defect: Breaks in coating

Possible causes

- ☐ Too high draw ratio
- ☐ Wire speed too fast
- ☐ Vacuum too high
- ☐ Contaminated resin
- ☐ Stock temperature too low

NYLON 6/6

Defect: Bubbling of extrudate

Possible causes

- ☐ Excessive moisture in resin
- ☐ Entrapped air: a) inadequate back pressure; b) poor screw design
- ☐ Melt temperature too high
- ☐ Hot spot due to faulty thermocouple (e.g., poorly located, broken, etc.)
- ☐ Hold-up in equipment (poor streamlining)

Defect: Weld lines

Possible causes

- ☐ Poor streamlining of breaker plate, etc.
- ☐ Adaptor (containing breaker plate) or die too hot
- ☐ Differential flow around mandrel, etc.—poor mandrel design

Defect: Reduced toughness

Possible causes

- ☐ Excessive moisture in resin
- ☐ Stock temperature too high
- ☐ Hold-up time too long—extruder too large for the job
- ☐ Holdup in equipment—poor streamlining
- ☐ Hot spot in adaptor or die
- ☐ Frozen-in stresses—poor control of freezing process
- ☐ Excessive drawdown—orientation
- ☐ Use of poor quality regrind

Defect: Erratic feeding (surging)

Possible causes

- ☐ Rear barrel temperature too cold
- ☐ Too much water cooling in hopper zone
- ☐ Poor screw design—e.g., no metering section, channel too deep
- ☐ Belt slippage in extruder drive
- ☐ Improper cut of resin, e.g., regrind

Defect: Fisheyes in film, bumps or pimples in shapes and tubing, etc.

Possible causes

- ☐ Insufficient plastication of the melt: a) extruder barrel too short; b) poor screw design; c) insufficient screen pack; d) output exceeds machine capacity
- ☐ Adaptor and/or die temperature too low—partially solidified material flaking off
- ☐ Dirty equipment
- ☐ Cross contamination of resin

Check list on ABS polymers prepared by Naugatuck Chemical Div., U. S. Rubber Co.; on Cellulosics by Celanese Corp. of America; on Nylon 610, PTFE, FEP resin, and Nylon 6/6 by E. I. du Pont de Nemours & Co., Inc.; on Polyethylene by Union Carbide Plastics; on Polypropylene by Hercules Powder Co.; on Flexible PVC by B. F. Goodrich Chemical Co.

Thermoforming sheet

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INTRODUCTION

By Robert L. Butzko[*] and E. Bowman Stratton, Jr.[*]

Vacuum forming accounts for the production of the majority of the thousands of jobs now being turned out by sheet forming. In this process, heating and forming take place in one machine, which may be manually or automatically controlled. After the sheet is heated, a vacuum removes the air from between it and a mold, and atmospheric pressure forces the softened sheet against the mold.

The following discussion deals with machines that form by straight vacuum or drape or a combination thereof or which are based on some variation of pressure or mechanical forming with heating in a separate oven.

Straight vacuum machines: One of the easiest types of forming at the present time is to use vacuum alone to pull a heated sheet into or over a mold. This type of forming may be performed on a special machine for straight vacuum only, or may be performed on one of the combination drape and straight vacuum machines that are on the market.

In a straight vacuum machine, the sheet clamp is usually attached to the mold or mold box, and is operated manually. In the combination machines, clamping is automatic. In the latter, the operator places the plastic sheet atop the mold and presses the starting buttons. The machine takes over, clamping the sheet, sending the heater over the sheet, heating for a timed interval, and opening the vacuum valve. After a timed cooling period, the vacuum is shut off, the clamp opens, and the formed piece is removed. The operator then inserts another sheet for the next cycle. With this type of operation, one operator may run two machines or may do other work such as trimming the formed parts. With the heater directly over the sheet and mold, split-second control of the heating cycle allows the vacuum valve to snap open when the exact molding temperature is reached.

Products made by this process are of the low-profile type, since the deeper the cavity, the thinner will be the plastic form. A rule of thumb generally used is that straight vacuum is used where the diameter of any opening is no less than twice the depth.

Straight vacuum forming over male mold: A variation of straight vacuum forming is vacuum forming on a male form placed in a cavity. This type of forming places the thickest part of the plastic part on the top, resulting in a stronger part. However, much more waste occurs since the plastic must be drawn down the sides of the female portion sufficiently far to prevent excess thinning at the base of the male plug. This type of forming was used extensively before the development of equipment for drape forming, described below. Some products with low profiles are still molded economically by means of this method.

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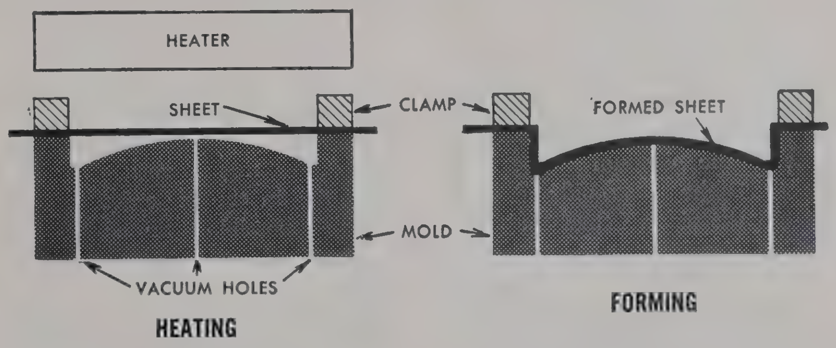
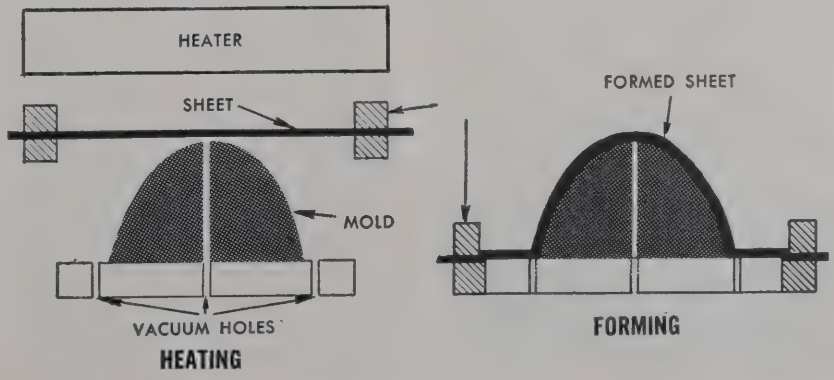
VACUUM FORMING OVER MALE MOLD



DRAPE FORMING



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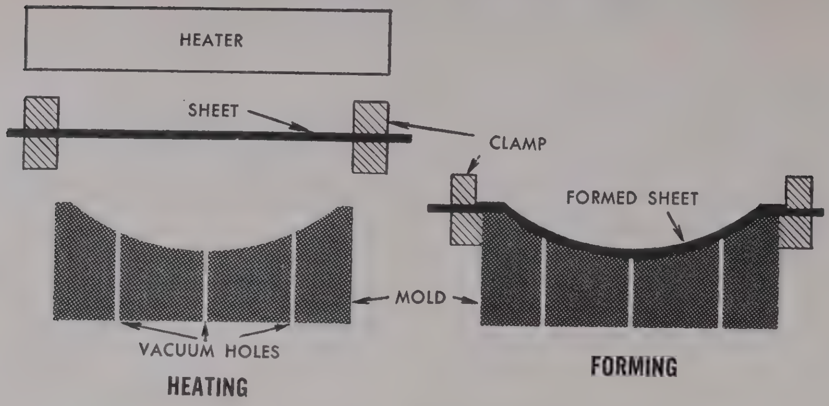
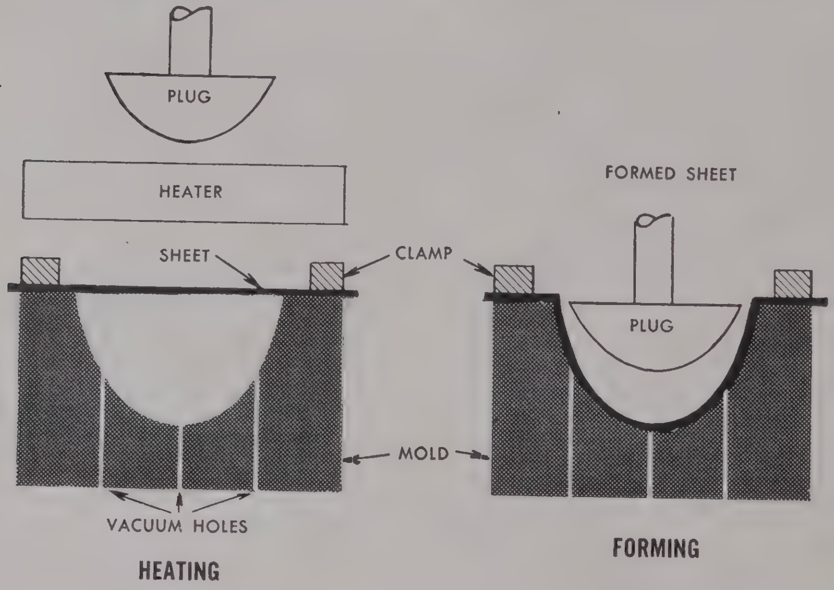
[*] Auto-Vac Co., 1984 State St. Ext., Bridgeport, Conn.

DRAPE FORMING INTO FEMALE MOLD



VACUUM FORMING INTO FEMALE MOLD WITH HELPER



process, vacuum is applied to the combination mold before heat is applied to the sheet. As the sheet softens, the vacuum drapes the sheet over the male mold and down around the sides. When the sheet is fully formed, the heat is removed. Proponents of this type of molding claim that greater accuracy of registration is possible since the sheet is immediately locked on the projections of the male mold.

Drape forming over male mold: By the drape process, plastic products can be formed with thick wall sections without extreme waste. In low-profile forms, parts may be formed either by straight vacuum or by the drape process; however, a better product can be formed from a thinner sheet by the drape process. In the drape process the plastic sheet is draped or pulled over the male form until the level of the sheet is down to the lowest height of the mold. The sheet is then sealed at the edges of the mold and the vacuum applied, pulling the sheet to the contours of the mold. Parts may have female sections within the male form, thus making possible the successful forming of many complicated shapes.

Refrigerator parts are among the high-production items formed by the drape process. The inner side of a door is a prime example. Formerly these doors were injection molded, usually on 200- or 300-oz. injection machines. Mold cost ran approximately $25,000 each and required from 14 to 20 weeks to obtain. Vacuum molds cost from $1200 to $2000 each and cutting dies from $2000 to $4000. These molds and dies may be obtained in about 6 weeks. With such low tooling costs, vacuum forming permits design changes to be made every year, whereas most injection molds are expected to remain in use for a period of at least three years to amortize the tooling.

Drape molding into female cavity: A variation of the drape process is draping into a female cavity. Some materials such as flexible vinyl or some of the heavy plastics will droop considerably upon heating and lock upon the mold, causing uneven products. By elevating the sheet in the heating process, the plastic is held far enough away from the mold so that the plastic sheet will not touch it. After heating, the sheet is draped in the conventional manner and the vacuum forms the part.

Automatic roll-feed drape forming: On one machine, the operation is completely automatic, requiring no operator in constant attendance. As many as 50,000 small parts per hr. are possible and such jobs can run 24 hr. per day without interruption. Unlike hand-fed operations in which slight variations of cycle require slight adjustments during the day, the completely automatic vacuum forming machine will run continuously without cycle variation.

Temperature-controlled molds are a must. They are heated to the required temperature before the first cycle. Any material now on the market may be used in any thickness which can be rolled without a permanent set. The usual thicknesses are from 0.005 to 0.040 inch. The average roll from 12 to 15 in. in diameter weighs from 100 to 150 pounds. With this equipment, the material, on a roll at one side of the machine, is drawn over the mold where the clamping, heat drape, and vacuum are applied automatically. At the end of the cooling cycle, the material is unclamped and indexed forward.

An average thin-walled package part may be run 3 cycles per min. in a multi-cavity mold. Since the finished parts are still in web form as they leave the machine, they may be fed directly into an automatic cutter or directly into loading equipment.

Forming into a female mold with helper: In order to reduce the thinning at the bottom of a part drawn into a female mold, a male plug may be used. In this case, after the plastic sheet is heated in place over the female mold, the plug is pushed downward against the sheet, drawing material from the sides into the bottom of the mold. Then, when the vacuum is applied, the bottom of the sheet has only a short distance to travel and does not thin out as much as with straight vacuum. This process has a disadvantage in that the plug will leave a mark-off on the sheet. The design of the plug is very important since just the right amount of plastic must be forced down to prevent thin spots from showing up in the side walls of the formed part.

Extrusion vacuum forming: One of the most economical processes is vacuum forming the hot plastic sheet as it emerges from the rolls or die of a sheet-extruder setup. Proponents of this type of forming emphasize that all scrap can be reground and fed back into the hopper of the extrusion machine. Utilizing the heat already in the sheet, the forming in some cases is done directly as the sheet is extruded. In other cases it is necessary to have additional heat, since the sheet cools rapidly as it leaves the extruder.

In one type of forming, the sheet emerges on a moving belt and the mold is manually dropped on it and travels with the sheet and belt. After the mold has made contact with the sheet, the vacuum is turned on and draws the plastic into the mold. After the mold has traveled with the sheet until the part is cooled sufficiently, the vacuum is turned off and the mold lifted off and reset on the next section of the plastic sheet. In a later type of machine, the mold is lifted and indexed automatically.

Snap-back forming: Another variation of vacuum forming is snap-back forming in which the sheet plastic is clamped on top of a vacuum box and heated. When the sheet has reached the correct temperature, vacuum is applied to the vacuum box, the sheet is pulled down to a predetermined depth, and male plug, lowered into the cavity, clamps air tight on the vacuum box. The vacuum is now released from the box, and vacuum is applied to the male plug. The vacuum pulling through the tiny holes in the plug snaps the sheet against the plug.

Some fabricators use vacuum in the box only. In this case, when the vacuum is released slowly, the natural tendency of most thermoplastics to return to their original flat shape causes the sheet to settle back against the plug. In this type of forming, however, reverse projections cannot be formed, but very little mark-off occurs and optical clarity of the material can be maintained. Snap-back forming is performed in an air press with an overhead piston and, as a general rule, the plastic is clamped in a frame and heated outside the press.

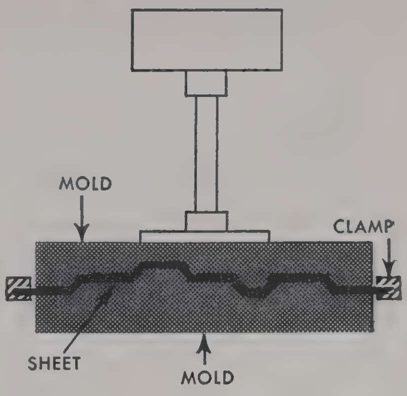
Free vacuum forming: For some types of forming where perfect optical clarity must be maintained, the plastic sheets can be molded into spherical shapes by free vacuum forming. Skylights, for example, are molded in this manner. The plastic sheet is clamped over a vacuum box and heated. When the sheet reaches the proper temperature, vacuum is applied, drawing the sheet into the box. When the part is of correct depth, the vacuum is reduced and held until the part cools. An electric eye circuit, actuated by the formed part when it reaches a predetermined depth, may be incorporated in the setup to control the vacuum.

Pressure forming

Since vacuum provides only about 14 p.s.i. pressure, better results may be obtained on some plastics and some products by using air pressure. Pressure up to 150 p.s.i. has been used. The equipment required is much heavier and consequently more expensive. Hydraulic presses with high ram speed and pressures from 50 to 200 tons are used and usually high-capacity hydraulic pumps are necessary. Heating the sheets is accomplished in a separate oven. Most of the early flexible vinyl place mats were formed this way. Although production is usually slower than vacuum forming, better detail results from the higher pressure. Unlike vacuum forming, only metal molds may be used since the pressures will break down other materials. Care must be taken in making the molds since the pressure will force material into any undercut and lock it in the mold.

Pressure forming into female mold: In this type of forming, a hydraulic press is used to clamp the mold with the pressure plate and clamping must be adequate to resist the impact of the pressure. The metal female mold is clamped to the press base and the pressure plate to the top.

PRESSURE FORMING

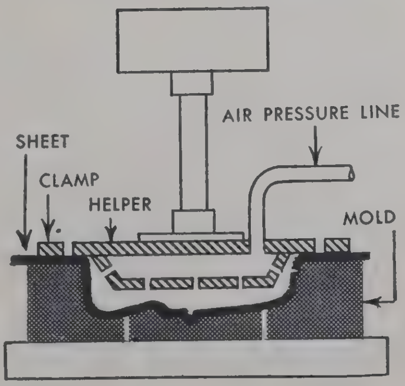


The plastic sheet is clamped in a frame and heated in an external heater to proper temperature. The clamp frame and plastic sheet are then transferred to the press and the press closed. Air pressure applied through holes which are in the pressure plate forces the plastic sheet to conform to the contours of the mold.

Pressure forming into female mold with helper: To reduce the thinning that occurs when forming into a female mold, a helper plug is sometimes mounted on the pressure plate.

Free blowing: Products requiring high optical clarity, such as aircraft canopies, may be formed by free blowing. In this type of forming, the plastic sheet is held in a clamp whose inside contour is the outline of the base of the finished product. The plastic sheet

FORMING INTO FEMALE WITH HELPER AND AIR PRESSURE



is heated and clamped over the top of a pressure box. Air pressure is then applied, blowing the plastic sheet to shape.

Mechanical forming

The oldest method of forming is by the use of straight mechanical actions without vacuum or air, and has many variations. Essentially, any sheet of correctly heated thermoplastic may be formed mechanically. Usually, heavy mark-off occurs so the products must be those where this factor is not objectionable. Sheet metal equipment such as crank presses, benders, air presses, rollers, and creasers are used, as well as special tools such as curling equipment.

Male and female dies: Forming by male and female molds is accomplished by using molds of almost any material. The best molds are of matched metal but these are also the most expensive. In this process, the sheet plastic is heated in an oven or on a hot plate. When at the proper temperature, the sheet is placed over the female mold mounted in an air press. The male part of the die, which is attached to the ram of the press, is lowered, shaping the plastic between the two halves of the die.

Plug and ring: A variation of male and female forming is the plug and ring, which has several different approaches. In this case, the plug and ring do not resemble the final part but the shape is drawn between the two. The plastic sheet, heated conventionally, is clamped over the ring and the plug is forced down into the sheet for a predetermined distance, forming the part.

Another method is to have a ring and a plug of smaller diameter, leaving just enough room for the plastic. The forming operation will produce a cup or shape with straight side walls.

A third variation, applied successfully for forming thin plastics sheets to shallow depths, uses a cold sheet. The male plug is heated and used on a slow-acting air or hydraulic press. The heat of the plug causes the plastic to stretch and form between the ring and plug.

Slip ring forming: In the previously described mechanical processes, the deeper parts stretch out considerably, resulting in thin side walls. In order to make a stronger part, a plug and ring setup may be used, in which the clamp exerts only low pressure. After heating conventionally, the plastic is held in this clamp and the plug pushed into the plastic to draw the part. The loosely-held plastic sheet will slip under the clamp and draw into the side walls, producing a part with thicker walls than would be otherwise possible.

Various types of clamping methods have been devised to control this slippage and to prevent the clamp from chilling the sheet being formed.

In a variation of this type of forming, a grease-covered mold is employed. The mold and the plug must be heated so that the grease film is actually liquid. This will reduce the mark-off which occurs from the slipping of the material.

THERMOFORMING: Acrylic

By W. W. Farr*

The outstanding optical or light-diffusing properties of acrylic, coupled with good mechanical strength and unsurpassed performance in prolonged outdoor service account for about 90% of the applications of the material in sheet form. Two types of acrylic sheet are produced: cast and extruded. For the *cast* material, major applications currently include: 1) outdoor signs; 2) boat windshields; and 3) aircraft glazing, including cockpit enclosures, windshields, and passenger windows. Cast sheet also is being used in outdoor fluorescent lighting fixtures, in glazing for skylights, and in corrugated roof and siding panels for application in building construction.

For *extruded* acrylic sheet, the major applications are in lighting fixtures for industrial and outdoor locations, in industrial glazing, and in corrugated panels for signs. The extruded material does not have the same high optical quality as the cast, but is lower in cost in the thinner gages. Thin extruded sheets are used for watch crystals, and in the range of 0.060 to 0.080 in. for laminated spectacle frames. Cast thick sheet, i.e., over ½-in., is used primarily for mechanical models and a variety of display and demonstration pieces.

Forming characteristics

In forming characteristics, the cast acrylics differ appreciably

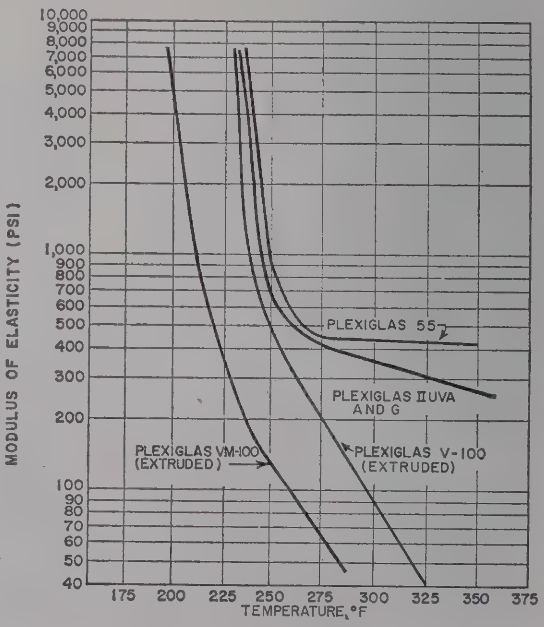


FIG. 1: Cast acrylic sheet, as compared with extruded, becomes progressively more pliable with increasing temperature and exhibits different forming characteristics

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* Technical service representative, Plastics Dept., Rohm & Haas Co., Washington Sq., Philadelphia 5, Pa.

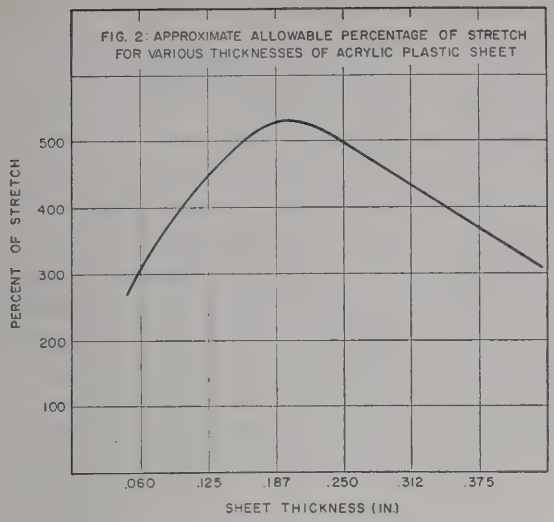

FIG. 2: In thermoforming acrylic sheet, the approximate allowable percentage of stretch varies with thickness. In curve at left, this percentage is plotted against sheet thickness

from the extruded types. As illustrated in Fig. 1, p. 702, the cast acrylics become progressively more pliable with increasing temperature, in conventional fashion. However, above a certain temperature they lose relatively little additional stiffness as they are heated further. Since the stiffness starts to level off at a modulus of about 400 p.s.i., the cast acrylics must be heated to about 50° F. higher than most other thermoplastics to permit forming at convenient working pressures. However, the compensating advantage is that precise temperature control is less critical, since the material, if moderately overheated, will retain sufficient strength to resist tearing or rupture during handling and forming. With most other thermoplastics, including the extruded acrylics, the sheet must be heated carefully since its mechanical strength drops off rapidly at temperatures above the usual forming range. However, this greater degree of softening by the extruded acrylics makes it possible to obtain better detail at low forming pressures or with vacuum.

Heating methods

Acrylic cast sheet has strong "elastic memory," which causes a formed part to tend to revert to its original flat sheet form when reheated to its forming temperature. This property permits fabricators to reheat and reform the material if an error is made during forming. However, the same heating operation should be used for flattening and reforming to avoid exceeding the maximum heating times which are given in Table I, below.

The three basic methods for heating acrylic sheet are by circulating hot-air oven, infrared sources, and strip heating. Ovens are practically mandatory for sheet ⅛ in. thick or over. The oven may be heated electrically or by gas. If by gas, the oven should be designed with heat exchangers so that heated air, rather than the combustion gases, heat the plastic. The air flow should be carefully controlled to distribute the heat evenly throughout the oven, so that each sheet will be heated uniformly over its entire surface and all sheets will be heated to the same temperature. Recommended air flow across the surface of the plastic is about 150 ft. per minute.

Infrared radiant heating may be used with relatively thin sheets. Its principal advantage is speed of heating due to the high surface temperatures of the heaters (600 to 1000° F.). Because the plastic is a relatively poor thermal conductor, exposure time to the infrared sources must be carefully controlled to avoid overheating the surface. Infrared heating should not be used on sheets over ⅛-in. thick when heated from one side, or over ¼-in. thick when heated from both sides. This method is generally not recommended for large sheets owing to the difficulty of heating large areas uniformly with individual heaters. Nonuniform heating can produce local stresses and poor optical quality in the formed part.

Strip heating provides a simple and practical method for heating acrylic sheet which is to be formed along a straight line. The heat source is generally a high alloy resistance wire enclosed in a ceramic or metal shield. The heating element should be shielded by a guard to prevent contact with the surface of the plastic; otherwise, the material can be badly distorted. The surface of the plastic should be no closer than 1/16 in., even for extremely short bends. For larger bends, a wider band of acrylic is heated, either by holding the sheet farther away from the

TABLE I: Recommended sheet temperature for forming acrylic

Type of forming	*Thickness of sheet, in.*					
	Group 1[1]			*Group 2*[2]		
	0.125	0.250	0.500	0.125	0.250	0.500
	°F.	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
Two-dimensional (drape)	245	240	240	290	290	290
Air-pressure differential without form (free-blown)	285	275	265	300	295	295
Stretch (dry mold cover)	285	275	265	320	300	300
Air-pressure differential with male form (snap-back)	295	285	275	340	320	320
Grease forming						
Air-pressure differential with female form Stretch with male form	320	300	285	340	340	340

[1] Based on Plexiglas 5009, Plexiglas VM-100, Implex; do not heat this group above 340° F., or for more than 1 hr. at 340° F.

[2] Based on Plexiglas II, G, Plexiglas 55, Plexiglas V-100; do not heat this group above 360° F., or for more than 1 hr. at 360° F.

heater or by using a wider heater. Sheets over ¼-in. thick should be heated from both sides to heat the entire thickness properly.

The proper forming temperature depends on the type and thickness of the material and the forming method used. Table I, p. 703, shows the suggested sheet temperatures for various forming methods and acrylic formulations.

Higher temperatures may decrease the tear resistance of the sheet and impair its physical properties without a visible change in appearance. Also, overheating softens the surface excessively and makes it more susceptible to fingerprints, glove marks, dirt pickup, and mark-off. Underheating is equally undesirable since the stiffness of the material increases about four times for each successive 15° F. drop in temperature starting at 10 to 15° below the recommended minimum forming temperature. Forming at too low a temperature can produce excessive internal stress with consequent crazing and dimensional changes in the formed piece.

Thinner sheets generally must be heated higher than thick sheets because the thin material cools off more rapidly when removed from the oven. Unusually thick sheets can be heated above the minimum required forming temperature and then allowed to cool slightly before being formed. In this way, the center of the sheet remains hot enough to avoid high internal stresses, while the surfaces are sufficiently cool to minimize mark-off from the mold.

The permissible time interval between the removal of a sheet from the oven and the completion of the forming process is 2 to 4 min. for ¼-in. material, but the time lag should be kept as short as possible. This can be accomplished by placing the forming equipment close to the oven, and by using efficient handling methods and suitable equipment such as quick-acting clamps.

Forming methods

Basic methods are discussed in the introductory article in this section; the following comments give details peculiar to the forming of acrylic sheet.

Drape forming: In drape forming, the edges of the sheet should be held onto the mold with continuous clamps to prevent curling. Best contour tolerances and optical properties can be obtained if the plastic is covered with a soft blanket or flocked rubber sheet so that it cools uniformly.

A variation of drape forming is *strip bending,* which is used to produce one or more sharp bends along a line. Channels are formed in this manner.

Plug-and-ring forming: With plug- and ring-forming, the bottom of the part is thicker than the sides because the relatively cool surface of the plug tends to freeze the plastic in place. Somewhat better uniformity of thickness can be obtained by using a heated plug to enable the material at the bottom of the part to distribute itself toward the corners during the draw.

Plug-and-ring forming produces mark-off at mold contact areas, particularly at the inside corners of the formed part. Because the mark-off is on the inside, it does not show on decorated, translucent, or opaque parts. As a practical limit, the depth of the draw should be no greater than half the minimum dimension of the ring opening.

Plug-and-ring with vacuum assist: With a vacuum assist, deeper draws can be achieved by plug-and-ring forming with less thinning of the walls. The sheet is clamped to a vacuum box and the material is drawn through the ring into the box by vacuum. At some point during the draw the plug is inserted to form the part to final shape. The depth of draw produced with the vacuum before the plug is inserted controls the relative thickness of the bottom and walls of the part. The initial draw by vacuum causes greatest thinning at the bottom; subsequent thinning of the walls when the plug is introduced therefore produces a part of more uniform cross-sectional thickness throughout. Owing to the better distribution of material, the practical maximum ratio of depth of draw to part opening is 1:1.

Snap-back forming: By this technique, all the stretching is produced by air-pressure differentials, rather than by the plug. As a result, the parts show appreciably less mark-off than is obtained with mechanical stretch forming, and have good optical properties.

Free-blowing and free vacuum forming: Free-blowing and free-vacuum-forming are used to form three-dimensional shapes solely with differential air pressure (either vacuum or positive) and without forms of any type. This technique provides the best optical properties and eliminates mark-off entirely because there

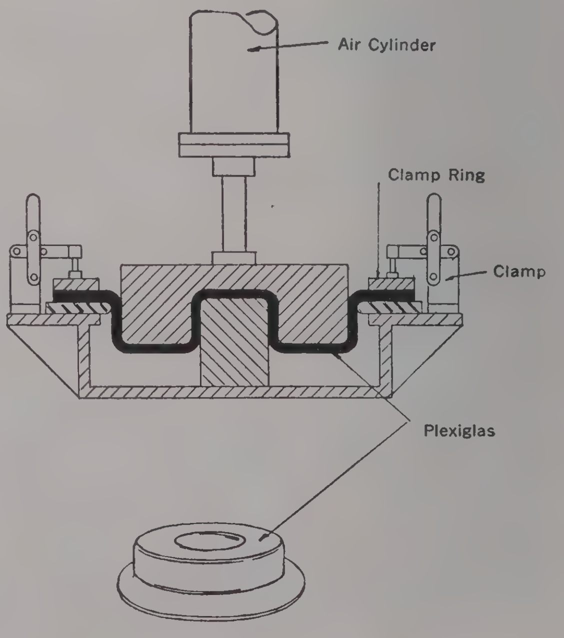

FIG. 3: In plug-and-ring forming, the hot sheet is clamped between mold and clamp rings, then pushed down to the desired depth by the male plug

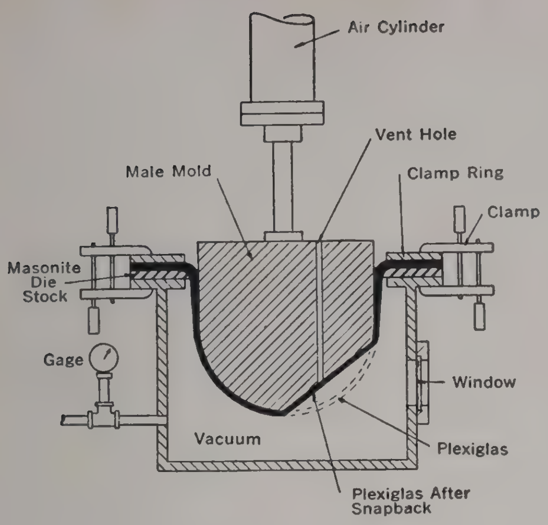

FIG. 4: In snap-back forming, a variation of vacuum-assisted plug-and-ring forming, stretching of the sheet is accomplished by air-pressure differentials rather than by the male plug

is no mold to touch the plastic surface.

Given a choice of the two methods for producing the air-pressure differential—vacuum or positive pressure—vacuum is preferable. Since the maximum differential attainable with vacuum is about 14 p.s.i., the forming process is limited to parts which can be formed at this pressure. Because vacuum forming is done in an enclosed vessel, the parts are less susceptible to rapid or uneven cooling from stray drafts.

The advantages of free-blowing with air pressure are that greater working pressure differentials can be used, and the tooling is generally simpler and cheaper. Free-blowing is most suited to forming large, spherical shapes. Because of the high pressures required, it is generally not a practical method for forming small area thick sheet (over ½-in.) or for producing small curvatures. The maximum useable working pressures are on the order of 60 to 90 p.s.i.

An inherent limitation of free-forming or free-blowing is that it is impossible to control the distribution of plastic as the sheet stretches. For a pure spherical shape, the material at the top of a hemisphere will be thinned out to about ⅓ the thickness of the material at the base.

Vacuum or blowing into female mold: This technique is quite useful for forming silk screened or painted surfaces where the decoration is on the inside of the piece, since it is the outside surface that contacts the mold. The process can be varied to vacuum or blow the hot plastics sheet over a male mold. If the sheets are predecorated on the inside surface, damage may occur unless special lubricants are used.

For a rectangular shape the recommended maximum draw should be no greater than ⅓ of the smaller dimension of the opening; for a circular or oval shape, the maximum draw can be increased to ½ the opening. For this work vacuum is used only to form fairly simple shapes and smooth flowing curves in thin sheet which can be handled with moderate pressure differentials. Small radii and precise contours, such as steps, require the higher differentials obtainable with positive pressure.

Variations in techniques

Ridge forming: Ridge forming is a technique of producing three-dimensional shapes using skeleton framework or "ridge" members instead of a solid contoured mold to form the part. Each plane surface in the three-dimensional shape must be enclosed by the skeleton framework. Thus, the ridge form for a rectangular box would consist of a framework of struts defining the bottom and sides of the piece.

Ridge forming can be used with plug-and-ring forming or with vacuum snap-back forming and is applicable to male and female molds. The primary advantage of ridge forming is reduced mark-off, since the plastic sheet comes in contact only with the framework members rather than with an entire mold surface. It is particularly useful for forming corrugated sheet, wherein the peaks and valleys of the corrugations are formed by parallel rows of ridges offset in the opposing halves of the mold.

Where possible, forms for ridge forming should be made with generous radii at the edges (at least twice the thickness of the acrylic sheet) and with larger radii at the corners to reduce the possibility of tearing the plastic at those highly stretched points. It is advisable to use materials having low thermal conductivity, such as phenolic laminates or Masonite die-stock, to prevent chilling the hot plastic too rapidly upon contact. If metal ridge molds are used they should be kept warm (150 to 160° F.).

The technique of ridge forming can be extended to constructing male and female forms to produce reverse curves, flanges, and fluting, with a minimum of distortion. This can be accomplished either with vacuum forming alone or in combination with positive pressure.

These variations in shape or curvature are obtained by partitioning off the vacuum box and controlling the pressure differential in each compartment with separate valves. The compartments are sealed off from each other by pressure of the plastic against the tops of the partitions.

Male and female forming: This process involves the use of matched male and female dies to form the part and emboss the surfaces at the same time. Both surfaces of the sheet are in continuous contact with the forms and will reproduce surface detail if sufficiently high pressures are used. This method can be used in conjunction with vacuum and pressure.

Blow-back forming: In blow-back forming, the acrylic sheet is clamped between a pressure box and an oversized clamping ring. The male form, shaped to the inside contour of the part, is then inserted, stretching the plastic to the required draw. Because the clamping ring is substantially larger than the male form, the

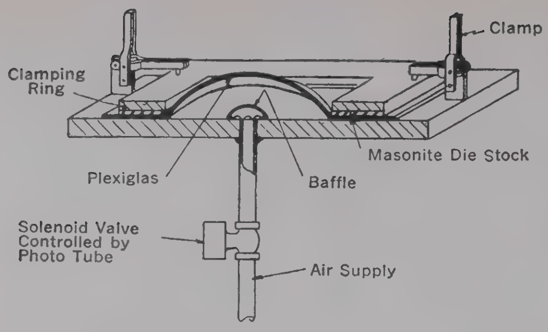

FIG. 5: No molds or forms are used in free-blowing of acrylic sheet. Forming is accomplished by differential air pressure, either vacuum or positive. Good optical properties and elimination of mark-off are provided by the use of this technique

plastic assumes a conical shape around the inserted form. Compressed air at 50 to 100 p.s.i. is then admitted to the pressure box against the outside surface of the plastic, forcing it to be "blown back" against the sides and bottom of the male form.

Blow-back forming produces less thinning of side walls because plastic is pulled from a larger blank area. It is best applied on cylindrical or conical shapes. For best results on cylindrical pieces, the area circumscribed by the clamping ring should be about three times the projected area of the part. The depth of the draw should be such that the surface of the acrylic (before blow-back) forms a 60° angle with the horizontal. On rectangular shapes the depth of the projection is limited by the amount of plastic which can be blown back around the corners without producing webbing (wrinkling).

Optical properties

Slow, uniform cooling, and the reduction of excessive internal stresses by the proper selection of the molding method and molding conditions, coupled with good mold design, are all basic to securing good optical properties when forming acrylic sheet. Mark-off can be significantly reduced by proper preparation of the mold surface.

For best optical quality when forming with a male mold, the following steps are recommended: 1) cover the mold with medium-density felt, saturated with a high-soap content petroleum grease; 2) heat mold to 160 to 175° F. and the surface to over 200° F. to convert the grease to a liquid film. This film minimizes mark-off by providing a lubricating film on which the hot plastics can slide as it stretches. The mold is usually heated by infrared lamps, and the acrylic sheet should be heated somewhat hotter than is usual for other forming methods.

For female molds, the same procedure is used except that the mold surface itself is greased with a polybutene grease. Generally, these precautions are not required for ordinary commercial parts and are used primarily for aircraft applications. They generally do not apply to forming pigmented and modified acrylic sheets.

The surface condition of the mold obviously plays an important part in the optical quality of the finished part. Thus, forms made from wood should be constructed from the side grain rather than the end grain of the wood. Metal forms which are cast by standard foundry techniques should be carefully finished because pits, blow-holes and other surface defects will be reproduced in the acrylic surface. Cast phenolic, epoxy, and polyester-glass reinforced molds are also in general use. Mold surfaces should be free of waves and other contour variations that might cause optical distortions. Surfaces usually are covered with soft cotton flannel, flannelette, velvet, or billiard felt. The nap of these coverings helps prevent mark-off from small dirt particles or irregularities in the surface of the mold. Three-dimensional forms can be covered with suede rubber or flocked rubber sheeting stretched to the form's contour.

For minimum mark-off, the molds should contact the inside surface of the plastics wherever practicable. Mark-off on the internal surface is visible in transparent material, but does not show through to the exterior of translucent material. The major exception to limiting mold contact to invisible surfaces is for applications where surface patterning or other surface effects are desired. For example, the exterior surface of lighting pans and fixtures can be made nonspecular to eliminate room reflections by forming the part against a sandblasted metal surface.

THERMOFORMING: Vinyl

By H. L. Burpo*

One of the oldest plastic materials used for thermoforming is vinyl. Sheeting made from both polyvinyl chloride and various copolymers is suitable. Of the copolymers, vinyl chloride-acetate is perhaps the best known and most widely used for thermoforming.

Regarded as well suitable for preprinting, rigid vinyl sheeting is used in over half of all preprinting applications, including formed signs, displays, and relief maps. Vinyl's suitability for such applications is a direct result of its uniform flow properties and good dimensional stability which permit undistorted preprinting registry. In the manufacture of vacuum formed panels for lighting and decorative wall coverings, the uniform flow characteristics of rigid vinyl sheeting, even in thin gages, permit the forming of striking designs.

Vinyls are not recommended where prolonged outdoor exposure is required. Also, calendered vinyl sheets are obtainable only up to 40 mils in thickness; planished vinyl sheets are available up to 500 mils (½ inch). Where end-use requirements are not critical, rubber-modified styrene has some advantage over vinyl because of its slightly lower cost and its availability in a wider range of unplanished thicknesses.

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*Agricultural Products Mgr., formerly Eastern Zone Mgr., Sheetings; Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 East 42nd St., New York 17, N.Y.

Rigid vinyl copolymers are easier to form, and they are used in a much wider range of forming applications than are the flexible vinyls. They are among the few materials which can be successfully drawn over a round plug 12 in. across and 12 in. deep, with a vertical side wall. Close temperature control of the mold—no higher than 120° F.—is important for good results when forming vinyl sheet.

Preprinting

As mentioned before, rigid vinyls are used in over half of the preprinting applications today. However, complete control of all forming operations throughout production must be maintained in order to obtain consistent results. Two-sec. variations in heating time are sufficient to throw the printing completely out of register. Care should be taken that the clamping frame be adequately warmed prior to forming so that the heat loss at the edge of the sheet from a cool frame will not affect the printing.

Applications

Sheeting: In the luminous ceiling field, there is an increasing trend toward vacuum formed panels as a supplement to the corrugated roll types. Thermoformed rigid vinyl has great uniformity of draw, thus enabling the formation of interesting and intricate designs with pleasing interior decorative effects.

A promising development in this area is the attempt to devise luminous panels with acoustical properties. One solution employs two formed panels joined at the edges. The air space thus created deadens noise but does not adversely impair the translucency of the ceiling. Another novel acoustical product is a formed and colored vinyl snap-on sheet for covering standard fibrous or mineral tile. And three-dimensional wall panels are being thermoformed which impart the decorative effect of exposed brick where real brick is impractical.

Relief maps are another important end use of formed vinyl sheeting. These maps have found widespread use in educational circles, in military training, and in the business world. The good forming characteristics and dimensional stability of rigid vinyl sheeting permit the intricate detail of the mold design to be produced in perfect register with the preprinted sheet. Because of rigid vinyl sheeting's impact strength, excellent tear resistance, and good ink retention, formed relief maps withstand repeated cleaning and constant handling.

Vinyl sheet forming has entered the area of food packaging in the form of single portion containers for jellies, jams, honey, sirup, and ketchup. The containers consist of small thermoformed cups filled with the food product and sealed on top with a printed vinyl film. In the same area is the thermoformed vinyl milk bottle cap. The high dimensional stability and strength of a specially formulated sheeting allows this cap to withstand repeated reuse by the consumer without losing its original shape.

Film: Cast vinyl films, both plasticized and unplasticized, used for thermoforming, have shown particular promise in "skin packaging." In this operation, the thermoformed film protects and tightly covers a given product while at the same time securing the article to a pretreated base board.

Plasticized cast film is used more frequently in skin packaging today than rigid cast vinyl because of its superior toughness, impact strength, and low temperature qualities. These properties can mean substantial savings. The extreme toughness of plasticized film makes possible the use of thinner film, and its low strain content and good dimensional stability means that thinner base boards can be used with no undesirable "board curling." Because of the low moisture absorption of cast vinyl films, "blushing" or "fogging" is completely eliminated.

Plasticized vinyls, in general, are not as easy to vacuum form as are the rigid materials. They form tightly against an article being packaged as the vacuum is applied but, upon release of the vacuum, they have a tendency to recover and "tent." To prevent this "tenting" and thus enable the plasticized film to take a definite set around the articles, adhesives must be applied to the backing board.

Unplasticized cast vinyl film has the highest stiffness modulus of any material used in skin packaging and, therefore, offers superb vacuum forming properties. Also, it requires the lowest cycle time, and is not limited by draw depth. Unplasticized cast vinyl has definite adhesion superiority—adhesion efficiency being determined by measuring the stripping force necessary to remove a film from the card. Since this film takes a definite set around the packaged article, the use of an adhesive on the backing board is not necessary. Unplasticized cast vinyl film has had limited use in skin packaging, however, because it does not have good low temperature or impact properties.

Vinyl films, both rigid and plasticized, can be formulated so that they will not tarnish metal. With plasticized film, however, caution should be used, as certain plasticizers will mar items coated with nitrocellulose lacquers or articles made of polystyrene.

THERMOFORMING: Styrene alloys

By William E. Welch*

Some of the lowest-cost plastics sheets for thermoforming are produced by the extrusion of styrene alloys of polystyrene and styrene-butadiene copolymers. These alloys are considerably tougher than general-purpose styrenes, but less transparent.

Low cost, however, is not the only advantage of styrene alloy sheets. Their forming characteristics are exceptionally good, they have good rigidity, excellent dimensional stability, and low specific gravity.

On the other hand, they do not

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* Senior sales engineer, Styrene Technical Service, Monsanto Chemical Co., Plastics Div., Springfield, Mass.

TABLE I: Heading cycle for high impact styrene alloys*

Sheet thickness	*Heating time*
(in.)	*(sec.)*
0.020	8
0.060	24
0.100	40
0.125	60

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* These values are approximate. They are based on a one-bank heating unit, set at 1000° F. and located 6 in. above the sheet. If there are two heating units, or if sheet is preheated, values would change accordingly.

weather well, they are translucent but not transparent, and they have relatively poor resistance to chlorinated hydrocarbons—mothballs, for instance.

Four types of styrene alloys are commonly thermoformed. They are conveniently classified as medium-impact, high-impact, extra-high impact, and high-impact-and-heat-resistant formulations. Of the four types, the so-called high-impact materials are most popular in large-volume applications. They represent about 70 to 80% of the total thermoforming market for styrene alloys.

Thermoforming techniques

Basically, the method for thermoforming extruded styrene sheet is relatively simple. The sheet is clamped in place, softened by heat, formed around a mold by vacuum (or pressure), allowed to cool, and removed.

It is important to work with sheet stock of high quality. Specifically, the extruded sheet should be of uniform thickness and relatively free of internal stresses. Actually, orientation as produced by excessive drawdown in the extrusion process or excessive calendering to produce gage control is the real danger, as it causes the sheet to thin out in the forming process.

Pinpointing the proper time to apply the vacuum is an important, but not too difficult, job. After the sheet is heated for a short time it begins to sag; then it becomes taut once more. This recovery indicates that the sheet is at the proper forming temperature (290 to 320° F.). At this point, the vacuum is applied.

Approximate heating cycles for high-impact styrene sheets of various thicknesses are listed in Table I, left. Cooling generally requires about half the time of heating of these sheets, but with sheet over 0.050 in. thick, the cooling time usually becomes greater than the heating time.

This basic forming technique has undergone a number of progressively improved modifications in recent years, all of which have been aimed at the manufacture of more dimensionally exact and/or more complex configurations.

Early thermoformers had a choice of only two methods. They could use "straight" vacuum forming (with female molds) or drape forming (with male molds). The point(s) at which greater strength was required in the molding usually dictated the choice. For example, if it was important to get more strength at the base of the part, a male mold was most often used.

More recently, "plug-assist" forming was developed to produce a more uniform wall thickness with a female mold. It has reduced thinning out of the sheet at the bottom of the mold. Many of the large manufacturers of refrigerators adopted this technique to form deeper, yet narrow, sections in their inner door liners.

Still more recently, the "air-slip" method of thermoforming was introduced. This system calls for a prestretching of the heated sheet prior to the forming operation by blowing. It does for the male mold what plug-assist does for the female mold: it makes possible a more uniform wall thickness.

The newest technique is the "air-cushion" method of thermoforming. It is similar to the plug-assist method but the heated sheet is stretched by streams of air forced up through the female mold. Subsequently, air is forced out the plug as it pushes the hot sheet into the mold but prevents the sheet from touching the much cooler plug which would, in effect, chill the section.

Table II, below, compares draw limitations of the various thermoforming methods.

Mold design

A particularly critical design consideration is the shape of the bottom section in a deep draw. Where vertical and horizontal walls meet, radii should be large (perhaps ¼ in. or more) for best results.

In upper areas of the mold, this is equally true. Best results here are obtained when sharp corners are avoided. It is suggested that 90° angles be rounded off to minimum radii of about 1/16 in. and that 160 to 180° angles have minimum radii of somewhere around ¼ inch.

Part shrinkage on cooling must also be taken into account; substantial variations will occur if some parts are trimmed immediately after forming and others are allowed to cool for, say, one hour.

Sometimes it is desirable to give the molded part extra built-in rigidity. Two techniques for accomplishing this are now popular.

On some of the newer molds, metal rods or strips are molded into the part. Caution should be taken, however, to keep an eye on temperature changes, such as might be encountered when shipping during winter months, which will build up internal stresses in the part, due to the difference in thermal expansion and contraction between plastic and metal. A

TABLE II: Draw limitations for various methods of thermoforming styrene alloy sheets

Type of forming	*Mold*	*Maximum depth ratio**
Vacuum forming	Female	1:2
Drape forming	Male	1:1
Plug assist	Female	1.25:1
Air cushion	Female	1.50:1

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* Depth ratio is ratio of draw to smaller dimension of horizontal cross-section. Figures given are conservative; limits depend on the quality needed in finished parts. A 5% taper will usually allow easy release from positive molds; no taper is needed in cavities because the parts shrink away from the mold on cooling.

STYRENE ALLOY formed parts are trimmed to exact dimensions by circular saw. Parts rest on fixtures which permit cut-off of just enough excess to bring part to required size

second method for improving rigidity calls for the designing of vertical ribs or flutes into large, flat areas of the mold.

Finishing

Originally, extruded sheets for thermoforming had a characteristic dull finish, unattractive from the marketing viewpoint.

To improve this surface finish, a method was devised whereby the hot sheets passed over highly polished, relatively cool rolls.

Better gloss and smoother finish were obtained by a second method: laminating a thin (0.002-in.) biaxially oriented styrene film to their surfaces. (This film can be preprinted to give the finished sheet a suitable design or decorative pattern.)

A third method has been developed more recently. The styrene sheet is passed under a series of heaters in order to "melt" the top surface of the sheet before it enters the roll nips. The result is a hard surface with good gloss.

Applications

Door liners for refrigerators and food freezers are easily the biggest use for sheet extruded from styrene alloys.

Disposable ice cream dishes: Throw-away dishes for ice cream, sundaes, and banana splits are gaining in popularity.

Displays and signs: These products are generally profile extruded, then decorated (often by silk screening), and assembled. Strictly for indoor use, such displays usually are made more effective by backlighting with fluorescent tubes.

Lighting panels: Some panels are being produced by thermoforming from medium-impact or high-impact styrene sheets. Sizes range up to 2 or 3 feet square.

THERMOFORMING: Low-density polyethylene

By A. G. Rowe*

The process for thermoforming thermoplastic sheet by mechanical and/or vacuum drawing has enjoyed rapid growth over the past five years. With this growth there has been increasing interest on the part of processors and end-users in the process for making products from polyethylene. Interest in polyethylene is based on the unique combination of properties offered by this material; i.e., extreme toughness over a wide range of temperatures, complete freedom from toxicity, and excellent resistance to attack by a large number of chemical agents.

Despite this interest, new products and packages formed from polyethylene sheet have been slow in making their appearance on the market. A careful analysis of the reasons for this discloses no flaw in the belief that polyethylene, because of its end-use properties, has an excellent future in the sheet forming field. The apparent slow growth in polyethylene forming can be explained in terms of the need for development effort in three areas.

First, a considerable degree of selectivity is required in picking end-uses where the unique properties of polyethylene are of most value. This selection having been made, an entirely new concept of product design is often involved and this means that a carefully planned and executed program of prototype testing is necessary. Such programs involve time. Thus, sound end-uses conceived today may not appear on the market for a year or more. End-use development work is frequently a cooperative effort on the part of end-user, processor, and resin supplier.

Second, processing characteristics of polyethylene are, to some extent, different from those of other forming resins in both the sheet extrusion and the forming operation. To cite a simple example, vacuum ports in a mold designed for polyethylene will be much smaller than in a mold for polystyrene. Differences in heating and cooling are noted later.

Finally, the success of end-use and process development efforts will usually be dependent on use of a resin with the proper characteristics. Resins tailor-made for sheet extrusion and forming have been commercially available for only a year. The need for tailor-made resins is underlined by the frequently unsatisfactory results of the earliest attempts at polyethylene thermoforming where resins designed for other uses were employed.

Processing characteristics

Heating: The need for extra heating is frequently cited as a difference between polyethylene and other forming resins. It is true that, with many heater banks, more heating time is required for polyethylene, largely because of its higher specific heat. However, with proper heater bank design, polyethylene sheet can be heated at satisfactorily high rates.

Factors which determine the time required to heat polyethylene sheet to forming temperature are as follows: heater density; heater rod temperature; sheet-to-heater-rod spacing; radiant energy absorption characteristics of the material; sheet thickness; and final sheet temperature re-

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* Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

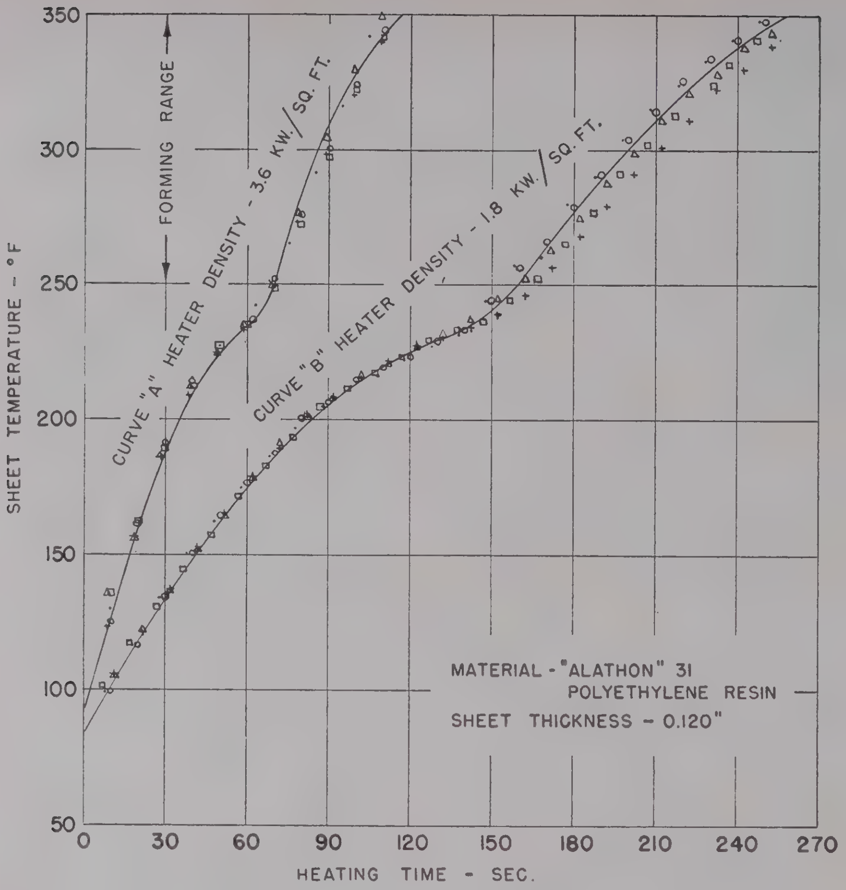


FIG. 1: Polyethylene sheet-forming temperature vs heating time. A) heater banks on both sides of sheet; B) heaters above sheet only

quired for the forming operation.

Heating time is greatly affected by "heater density"—a convenient term for describing the ratio of electrical power input to the heater bank (kilowatts) to total area of the heater bank (square feet). The benefit of high heater density is illustrated by the two curves shown in Fig. 1, above. Data points for these curves were obtained as follows: A hole, 1/16 in. in diameter and 1½ in. deep was drilled into the edge of a 0.120-in.-thick sheet of polyethylene resin. A thermocouple was inserted into the drilled hole, the sheet was placed in the clamp frame of a forming unit, and the frame was rolled into the heating oven which was equipped with radiant heater banks above and below the sheet. Sheet temperature was read at 10-sec. intervals until it reached approximately 350° F. This is above the highest temperature normally used in forming. This procedure was repeated five times with sheet heated from both sides, then five times with sheet heated by the upper heater bank only. For each curve in Fig. 1, points for all five runs are plotted to show the extent of variation in data. Curve "A" is the plot of sheet temperature *versus* heating time with radiant heater banks above and below the sheet. These banks provided a heater density of 3.6 kw./sq. foot. Curve "B" is the plot for identical sheets heated with the upper heater bank only. In this case, heater density was reduced 50% to 1.8 kw./sq. foot. With the upper heater bank alone, 160 sec. of heating or about 1.3 sec. per mil of thickness were required to reach 250° F., the lower end of the forming temperature range. Doubling heater density by use of both heater banks reduced time for heating to the same temperature to 70 sec., or about 0.6 sec. per mil of thickness. This is near the highest heating rate which can be used for some of the other forming resins without danger of causing surface bubbles or blushing. Polyethylene showed no tendency to bubble or blush at the 3.6-kw./sq. ft. heater density. Limited experience with a 5.8-kw./sq. ft. heater bank indicates a heating time of 25 sec. for 0.080-in. sheet, or, about ⅓ sec. per mil of thickness. Again, no adverse effect from the rapid heating was noted. In short, the practical solution to the problem of rapidly heating polyethylene sheet involves a moderate investment in a high-density heater bank.

Operation at maximum heater-rod temperature to obtain fast heating is both effective and economically sound. It is true that as heater temperature increases, a greater proportion of the energy emitted is in the short wavelengths which the sheet will not readily absorb. This means the electrical energy supplied to the heater bank is utilized less efficiently at maximum temperature than at a lower temperature. However, the total energy emitted is proportional to the fourth power of absolute temperature. As heater temperature increases, there is a big increase in energy emission at all wavelengths. The resultant gain in sheet heating rate outweighs by far the penalty in reduced heater efficiency.

The optimum sheet-to-heater-rod spacing is the minimum distance that can be used without producing a rod pattern on the

TABLE I: Minimum heating time for various thickness of low-density polyethylene sheet

Sheet thickness	*Heating time*	*Heating time per unit thickness*
in.	*sec.*	*sec./mil*
0.020	18	0.9
0.060	36	0.6
0.100	48	0.5

heated sheet. Spacing is not critical except where the sheet being heated is nearly as large as the heater bank. In such a case, spacing should be close enough so that no part of the sheet can "see" a cold surface.

While total heating time required is increased as sheet thickness increases, the increase in heating time is not directly proportional to the change in thickness. To illustrate, display racks were made from 20-, 60-, and 100-mil sheets of the same polyethylene resin. For each sheet thickness the forming unit was operated on a semi-automatic cycle and the heat timer setting was reduced stepwise until the sheet tore repeatedly on being draped over the mold. The time was then increased in 1-sec. steps until the sheet would consistently form without tearing. Table I, p. 710, lists this minimum heating time for each sheet thickness.

For thicker sheet, the heating time per unit of thickness is lower than that for thin sheet. This is largely due to the fact that the surface-to-volume ratio is lower and the heat lost to convection currents across the sheet surface represents a smaller percentage of the heat being put into the sheet.

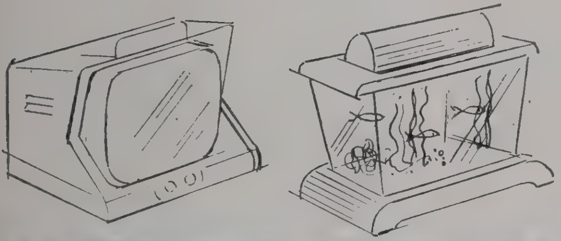
Sheet temperature

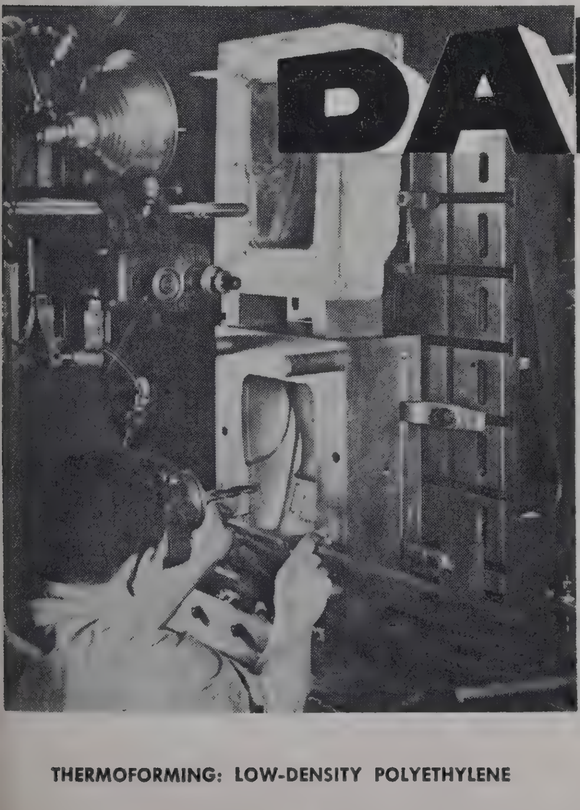
The final sheet temperature required for forming a given sheet is influenced by a number of factors. Forming temperature increases with an increase in depth of draw, with a decrease in melt index of the resin, where fine detail in the mold is to be reproduced accurately, or when the mold is operated at a low temperature. Resin density is an important factor. For the display rack, sheet of 0.914 density could be formed at 225° F. while 250° F. was required to form sheet of 0.930 density.

It should be noted that the above comments on heating apply to resin of natural color. Heating rates for pigmented sheet are likely to be higher, the size of the difference being dependent on the amount and type of pigmentation.

Cooling: With respect to cooling sheet after forming, there are three minor differences between polyethylene and other forming resins. First, polyethylene conducts heat faster than other forming resins. Thus, heat from polyethylene sheet is transferred to the mold more rapidly and the effect is to reduce the time required for cooling. Second, polyethylene has a higher specific heat than do other forming resins; thus more heat must be put into the sheet to soften it and more heat must be removed after forming. The effect is to increase time required for both heating and cooling. Third, the stiffness of polyethylene is low at high temperatures. In some, but not all, cases it may be necessary to cool polyethylene to a relatively low temperature before stripping from the mold. This requires more cooling time.

Provision for control of mold temperature is an effective and simple solution to the problem of cooling formed sheet rapidly. Control of mold temperature also eliminates the opposite extremes of chill marks on the sheet caused





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by contact with a cold mold or having the sheet stick to an overheated mold. The following data for a display rack, drape-formed over a mold equipped with a temperature control coil, show typical cooling times for Alathon[1] 31: with the mold at 120° F., the 20-mil-thick shape was cooled in 7 seconds. Raising mold temperature to 190° F. increased cooling time to 8 seconds. In each case, the display rack was cooled only enough so that it was not distorted on being stripped off the mold. With the mold temperature below 120° F., chill marks were seen on the sheet while 190° F. is near the upper limit for rapid cooling.

The unique combination of end-use properties and processing characteristics which can be designed into polyethylene resin promise an excellent future for this resin in thermoformed products. Progress is dependent on development work in the areas of end-use testing, processing techniques, and resin properties.

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[1] Alathon is the registered trademark for Du Pont's polyethylene resins.

THERMOFORMING: High-density polyethylene

By Frank L. Quinby, Jr.*

The thermoforming of polyethylene is of great interest to plastics fabricators and the advent of the linear or higher density types has widened the choice of materials and the potential fields of use.

Polyethylene, broadly speaking, is of interest as a forming material because of its toughness, the wide range of temperatures over which it is useful, and its excellent resistance to chemicals. The processing characteristics of polyethylene are different from other forming resins basically because of the crystallinity of the material. For general descriptive purposes, polyethylene sheet-forming materials are divided into two groups, the low-density or conventional types; the medium- and high-density or linear types. The first group ranges in density from 0.91 to approximately 0.93 and has generally low crystalline content. The second type ranges upward through 0.96 in density and has generally high crystalline content.

Processing characteristics

One of the most common complaints from thermoformers is that the heating cycle for polyethylene is too long. This, of course, is due to several factors: 1) most of the machines in use today have been designed for acetate and styrene and have a lower heat density than is recommended for polyethylenes; 2) the specific heat of polyethylene is higher than most other thermoplastic sheet materials that are thermoformed; 3) there is a phase transition from the crystalline to the amorphous state, particularly in the linear type; and 4) the temperature of forming is generally higher.

It is possible to shorten the heating period by adding additional heating units in the existing heater frame. Sandwich-type heaters are recommended if they can be physically incorporated. Also, sheets can be partially preheated in an adjacent oven.

All of the recognized methods of forming will work with polyethylenes. The shrinkage rate is different than for other materials, so parts formed on molds made for acetate or styrene may not give a good fit. Manufacturers should be consulted as to the shrinkage rate for the particular polyethylene being formed.

Heating and cooling

In general, polyethylenes require somewhat longer forming and cooling cycles than other thermoplastics. Since they form at higher temperatures, it is necessary to take more heat out of them before they set. Also, it is desirable to take the heat from the sheet in as uniform a manner as possible. Due to a characteristic of polyethylene, the material will pock mark badly if shock cooled on the forming die; it therefore has generally become accepted practice to run the dies as hot as possible with a consequent lengthening of the over-all cycle.

The cooling can be accelerated by means of fans, fog nozzles, etc., but care should be taken not to mar the soft surface of the material before it sets up. In general, the forming and cooling cycle should be held to a period not longer than the heating cycle. Warpage is largely caused by uneven cooling of the formed piece. If uniform cooling can be obtained, warpage will not be a problem. Warpage can also be reduced if the part is trimmed promptly after forming. Some strains are set up in the piece by leaving the unannealed section which was in the clamping frame on the unit.

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* Technical Service Dept., Polymer Chemicals Div., W. R. Grace & Co.

Mold design

Pressure-cast aluminum molds with vapor-honed or sand blast finish and with temperature control coils cast in place give best results with polyethylenes. High temperature cast epoxy molds work well for limited runs and in many cases temperature control coils are not required. It is essential that generous radii be allowed on all corners; that careful design work be done to prevent bowing of sides; and fluting or ribbing of all large flat surfaces is recommended to minimize warpage and distortion. Since polyethylene at forming temperature is actually a viscous liquid, it gives very close characterization of all mold surfaces. Vacuum holes must be very small or the material will follow into them. Tapers or drafts on the sides should be in the area of 5 to 10° on male molds. On female molds, vertical sides are possible.

Reference

"Choosing and forming polyethylene sheet," by A. G. Rowe, MODERN PLASTICS 35, 113 (Aug. 1958).

THERMOFORMING: Cellulose acetate

By Tom Sondberg and
Walter Ronayne*

One of the most versatile and relatively inexpensive thermoplastic materials that can be thermoformed into a variety of useful items, cellulose acetate is available in a wide range of

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* Technical Sales Engineers, Plastics Div., Celanese Corp. of America, 290 Ferry St., Newark 5, N. J.

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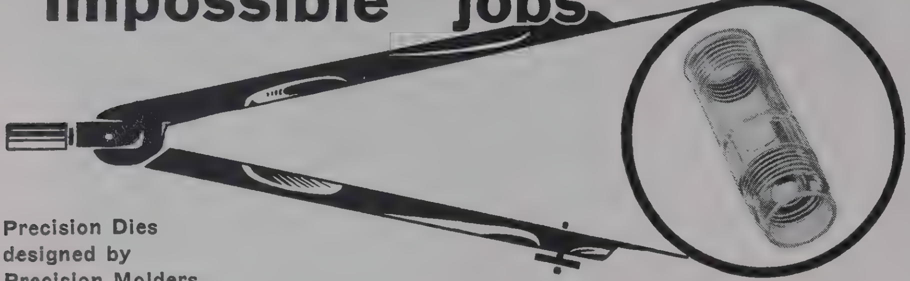

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By far, the most extensively used thermoforming or fabricating procedures today are those employing vacuum or compressed air. We shall concern ourselves here with the vacuum forming technique. Sheet temperatures of 300 to 325° F. are required, and it is important that this temperature be reached quickly to avoid "baking out" the plasticizer.

Infra-red, Nichrome wire, strip, coil, quartz lamp, Calrod, or Glascol heaters capable of maintaining a temperature of 900 to 1000° F. ±10° F. are required. If some areas are over- or under-heated, it is advisable to attach baffles or masks to the hotter sections rather than to lower the over-all heater temperature. These baffles may be either solid or perforated, but must be of noncombustible materials, and are placed beneath the heaters to deflect or absorb part of the heat energy.

Solid type baffles such as light-gage aluminum or sheet metal are very effective if one wishes to form preprinted sheets and yet avoid distortion of the printed areas. Such baffles are also employed if a formed piece is rather shallow-drawn and has a large unformed surface, since there is no need to heat this unformed area and the original clarity of the piece is better maintained. Perforated baffles, i.e., ordinary insect screening or up to ½-in. mesh openings, are especially helpful in distributing heat to specific areas of a sheet when the mold being used to form the acetate sheet contains many plugs or cavities.

---

[1] Local laws usually permit use of acetate sheeting for these purposes.

It is generally easy to determine when the acetate sheet has reached the recommended 300 to 325° F. forming temperature by watching its behavior during the heating cycle. The sheet will first appear to wrinkle or corrugate, then go into a sag, and finally "drum up" or "shrink" to a taut position. The point at which the sheet exhibits signs of shrinking or drumming up is the proper time to commence the draping action. Full or part vacuum should be applied quickly and the heater withdrawn. Heavy-gage acetate may or may not drum up, depending upon the area of the sheet being formed. The weight of large-area sheeting will counteract part or all of the tendency to shrink back and its proper forming point is determined when the sheet appears to remain "static" or level off from its initial sag.

A sheet is underheated if there appears to be any localized color change on the formed piece; crystal or colored transparents will have bluish white or smoky areas, and colored opaque sheets will show areas of sharp color variation. Overheating is evident if the surface is "blistered" and there is an exceptional amount of webbing or flowing of material into vacuum holes.

Heating time depends upon the gage of the sheet being formed, heater temperature, and the distance of the heater from the clamped sheet. It is usually 1 sec./mil of thickness up to 10 mils, 0.7 sec. for 15 to 20 mils, 0.6 sec. for 30 to 60 mils, and 0.5 sec. for 70 to 80 mils. These rates should be maintained by increasing or decreasing heater temperature or heater distance from the clamped sheet.

Forming the sheet

Once the sheet is heated, it is important that it be draped quickly before its heat is dissipated into the surrounding air. Thin gages, therefore, must be draped faster than heavier-gage sheeting (0.020 in. and up), and where the heater must be withdrawn before the drape action can commence, the movement

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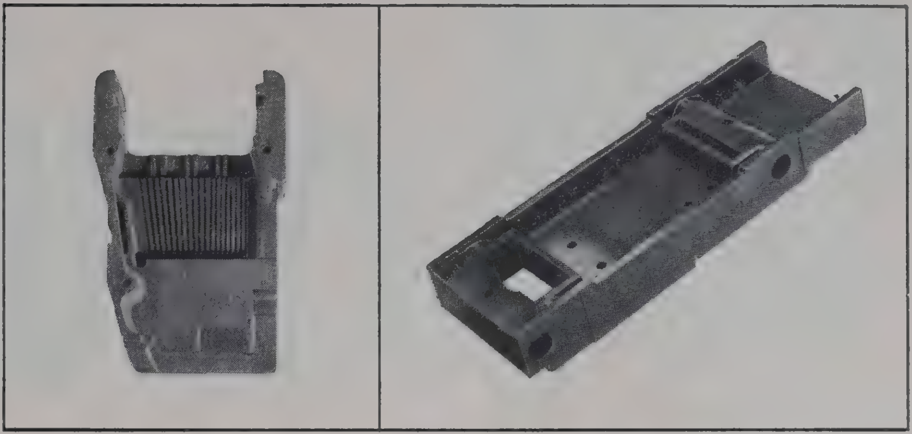

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must be very fast. However, there must be no "ballooning" or entrapment of excessive amounts of air between the mold and the sheet because this is likely to make webbing appear along the edges of the mold.

Cellulose acetate requires mold temperatures of from 125 to 150° F. to prevent premature setting or chilling of the formed sheet before it can conform to the detail of the mold surface.

Satisfactory forming, especially of heavy-gage sheeting, requires some cooling of the piece on the mold; hence it is best to reduce mold temperature build-up by circulating cool water through tubing incorporated into the core of the mold. Cast phenolic, plaster, and uncooled metal molds, although less costly, do not lend themselves to high production of quality pieces because longer cooling on the mold is required and the molds accumulate plasticizer more rapidly.

Mold design

The greatest possible number of vacuum holes should be used in the initial mold design, and it is important that they be located at the last point of contact to avoid air entrapment which usually prevents complete forming to the mold surface. Holes 0.010 to 0.015 in. in diameter are satisfactory and they do not mark the stock because the hot sheet will not flow into them. These holes should be relieved on the underside of the mold to about ¾ of their depth and enlarged to approximately 0.250 in. in diameter. Male molds usually require holes only near the base of the contour, while cavities require them at the lowest points. Test formings will show if the vacuum holes are too large or numerous; they can be partially or completely plugged by inserting toothpicks or drops of solder.

Drape or ring assists are helpful in overcoming thinning out and webbing on tall male molds. Usually constructed of rods or bars, these assists are attached to the top of the clamping frame above the sheet and are aligned to push the draped sheet over the plug quickly, thereby avoiding uneven wall thickness. They

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should be strong, but as thin as possible, because they will act to baffle the heaters.

Assists are also necessary on certain female or cavity molds to assure uniform wall thickness. Molds are normally made from a metal, wood, or thermosetting material such as a metal-filled epoxy.

To prevent any marking of the formed sheet, molds should be free of sharp corners and the surface very smooth. The temperature of the plugs is also of importance to prevent sudden "shock chilling" when they touch the sheet during the draping action. The recommended plug temperatures are usually between 200 and 250° F. However, exact temperatures can only be found by trial and error for a particular gage sheet and part design.

THERMOFORMING: ABS polymer blends

By George S. Laaff[*]
and Sam G. Grillo[†]

The ABS (acrylonitrile-butadiene-styrene) class of materials has a combination of excellent physical, chemical, and forming properties which make it useful in many applications where clarity or transparency are not essential. Industrial applications already include boxes and cases of all types and descriptions, machine housings, interior automotive and aircraft trim, etc.

ABS polymer sheets can be thermoformed by many available methods including vacuum, ring and plug, drape, vacuum snap back, air slip, etc. The foremost requirement in the forming of thermoplastics is a uniform temperature throughout the sheet. A sheet temperature in the range of 275 to 325° F. is required to soften ABS material prior to shaping. Several methods of heating can be employed in the forming operation.

1) Steam or electrically heated

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[*] Mgr., Research and Development Dept., and [†]Group leader, Thermoplastics Sheets, Bolta Products Div., The General Tire and Rubber Co., Lawrence, Mass.

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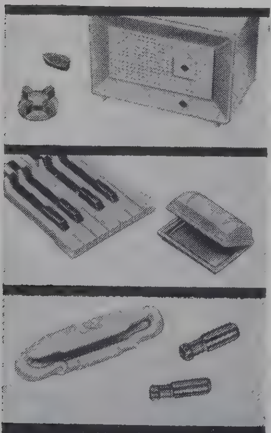

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platens. Duration of heating time is dependent on the thickness of the sheet and the time lapse between heating and the actual forming operation.

The following table can be used as a guide for establishing proper heating procedures when heated platens are used:

Gage in.	Platen temp. °F.	Time min.
0.016-0.032	310-320	½-¾
0.047-0.062	310-320	1½-2½
0.062-0.093	320-330	2-3½
0.093-0.125	320-330	3-5
0.125-0.250	320-330	5-12

2) *Air circulating ovens.* Uniformity and low temperature gradients make this a good heating method for sheet stocks. The oven temperature should not be much higher than the desired forming temperature. No set rule as to time of exposure can be given since it will depend on the size of the oven and the amount and velocity of air available. The oven can be equipped with perforated or grilled shelves. To assure uniform heating the blanks should be rotated.

3) *Infra-red radiant heaters.* This type heater is rapidly becoming the most popular. It makes use of the relatively long infra-red wavelength which is not too sensitive to color. Fast cycles are obtained using this method, but caution must be exercised to prevent overheating by the use of proper controls.

During the heat cycle, ABS-blend sheets will shrink as much as 10% in the direction of take-off during extrusion. There will be a slight expansion in the opposite dimension and a slight increase in thickness.

Regardless of the type or source of heat, it is extremely important that the stock temperature be maintained within the prescribed range (275 to 325° F). Overheated stock will blister or burn. Hot spots will result in excessive thinning or tearing. Cold stock will not produce the desired detail. ABS-blend sheets conduct heat slowly (as do most plastics). Thus, an attempt to shorten heating times by increasing heater temperature can result in excess scrap due to surface blisters and discoloration. It may sometimes be desired to have greater thickness in certain areas of a molded part.

TELEVISION SET rear panel was formed of ABS resin sheet by plug-and-ring method. Mounting holes and other openings were drilled and blanked after sheet was formed. (Photos, Bolta Products)

This can be done by either masking the section of sheet or by directing a cold air jet on the area to retard temperature rise.

"Plastic memory" is inherent in formed ABS-blend sheets. When a formed part is reheated to 200° F. or above it has a tendency to return to its original state. This is advantageous in reworking, as a sheet can be reformed if not formed correctly the first time.

Forming machines are usually equipped with the controls necessary for automatic cycling. Retractible radiant heaters are used. To determine the proper heating cycle and insure uniform temperature throughout the sheet, it may be necessary to use a sample sheet with temperature-sensitive devices (thermocouples, "Tempilaq", etc.) placed at several points on (in) the sheet. The heating time, distance of the

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heater above the sheet, and heat temperature are varied until the required forming conditions are reached. Once these settings are established, they are maintained for forming sheets of the same thickness throughout the production run.

Molds used in forming of ABS-blend sheets are relatively inexpensive. They can be made from a variety of materials ranging from plaster to steel. For large production runs, molds are usually steel or cast aluminum. These materials are more expensive than plaster, wood, or plastics, but trimming devices and mold temperature controls can be added which will shorten the over-all cycle. The temperature can be controlled by circulating water through the mold. For best results, the mold temperature should be about 150 to 160° F.

Vacuum-forming molds should be drilled with $\frac{1}{32}$ in. holes. The distribution of these holes is determined by the design of the part and the detail required.

Mold shrinkage is normally about 5 mils/inch.

In designing a mold, radii should be kept as large as the design of article will permit, and should never be less than the *original* sheet thickness. Right angles should be avoided and usually 3 to 5° of draft should be allowed. Wherever possible, curves or ribs should be included in the part design to give it greater rigidity.

Because of the inherent toughness of formed ABS-blend sheets, cutting or trimming does not present many problems. Woodworking tools, such as band saws, circular saws, drill presses, sanders, etc., can be used. It can be punched or blanked on clicker dies or on shears without preheating.

These materials are available in various thicknesses, grains, and opaque colors. Their compatibility with other resins and modifiers also allows a range in hardness from leatherlike softness to Rockwell "R" values of 100 or more.

Ordinarily, outdoor usage is not recommended because the sheets discolor, chalk, and craze. The physical properties remain substantially unimpaired.

Blow molding

By G. S. Brown*

The presently expanding interest in blow molding is chiefly the result of the availability of improved materials. Such improved materials exhibit excellent properties for this production method and, at the same time, are broadening the scope of plastics countainer packaging.

Most important for consideration in the manufacture of blown plastics bottles is selection of material, since it also governs what can and cannot be packaged. Over-all requirements for a material to be used in a blown container are:

1) It must not dissolve or react with the contents.

2) It must not swell or lose rigidity and shape.

3) It must have sufficient mechanical strength (known as stress-corrosion resistance) to prevent cracking from plug pressures, cap pressures, or other forces.

4) It must not impart taste or odor to the contents.

5) It must have adequate flow characteristics to make possible the manufacture of a package with good appearance.

6) It must not deteriorate with age under all normal conditions of use.

7) The annual loss of the contents by permeation through the bottle walls should not exceed 3% of the net content.

Generally speaking, any thermoplastic showing easy biaxial orientation at the temperature of blowing and having stretchability over a wide range can be blow molded. It is also important that the viscosity remains relatively unchanged over a limited temperature variation for processing on a practical basis.

Methods of manufacture

The machinery and processes used for blowing bottles are primarily custom built by the bottle manufacturers, and the release of detailed information concerning the machines is closely controlled.

A number of different processes are used for manufacturing different types of blown containers. Basic methods and variations are illustrated in the figures which appear on p. 722.

First basic method: The plastics granules are heated and compounded by conventional means to a state suitable for extrusion. The compound is then extruded in the form of a tube (Fig. 1) and two mold halves, cored to the shape and dimensions of the required bottle, are closed around the tube. In closing, the end of the tube forming the bottom of the bottle is pinched and the tube is inflated by air introduced into the open end. It expands against the surfaces of the mold cavities and chills into that shape.

There are a number of variations and refinements to this method of blowing bottles. The tubular plastic can be extruded continuously or intermittently from a single extrusion orifice and the molds indexed into proper position before closing around the tube. The tubing is blown by introducing air through a center opening in the extrusion orifice to form the bottle and is then severed from the extrusion head. The molds are indexed, advancing the blown bottle to a second station for cooling, while another mold set moves into position around the plastics tube to form the following bottle.

In a second variation, the tubular plastics is extruded continuously from a single orifice and molds are positioned around the tubing and closed while moving continuously away from the orifice. (See Fig. 2.) The closed molds are replaced by a following set of open molds. The tubing is pinched at both ends of the closed molds and inflated through a "needle" that punctures the tube.

A third variation provides a manifold as an integral part of the extrusion head containing a number of extrusion orifices. (See Fig. 3.) Plastic tubing of the proper length is extruded from the first orifice and a pair of blow molds closed around the tubing. As a valve controlling the flow of plastic to the first orifice is turned off, a valve to a second is opened. This sequence continues for the number of extrusion orifices and blow mold stations of the machine and the cycle then repeats. Air is introduced into the tubing through a central hole in each extrusion orifice.

Second basic method of blowing plastics containers is to make a preform by injection molding, then reheat the preform and blow it to its final shape.

In one version of this method, the resin is injection molded around a hollow core approximately the length of the finished container. This molded preform has the appearance of a laboratory test tube with the closure threads molded on the open end (Fig. 4). This preform is then either reheated and blown into a container as a second operation, at a later time, or is transferred immediately to a blow station and blown by admitting air through an orifice in the hollow core. The bottle is removed as a completed product and usually requires no trimming.

An alternate method of manufacture (Fig. 5) provides for premolding those portions of the container which can be formed without blowing (such as the neck) and then extruding a hot tube integral with the molded section of a length slightly longer than the desired container. A blow mold is then closed around the tube, pinching the open end which forms the bottom of the bottle and blowing the tube into the cavity of the mold.

Third basic method of forming bottles consists of first making sections by vacuum or pressure forming from sheet, and then heat-sealing the sections together into a finished product.

In a variation of this process, two sheets of plastic are extruded parallel to each other. Cavities

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*Mgr. of research, Plax Corp., P.O. Box 1019, Hartford, Conn.

FIG. 1 BASIC PINCH-TUBE PROCESS

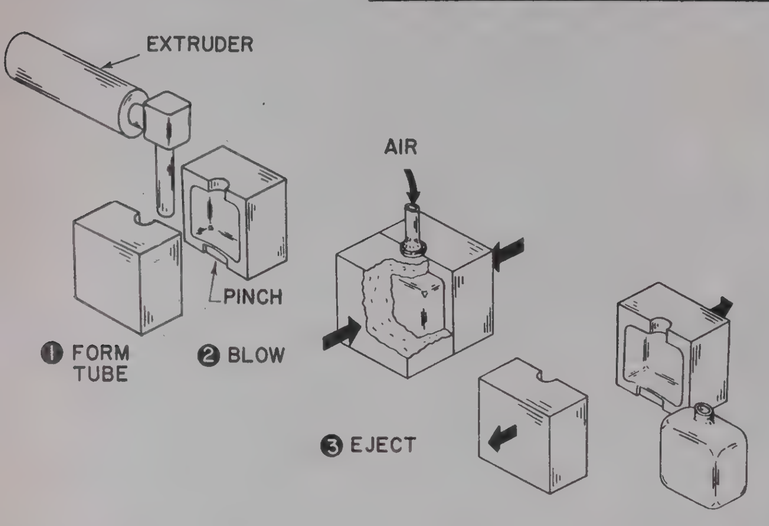


FIG. 2 CONTINUOUS TUBE PR

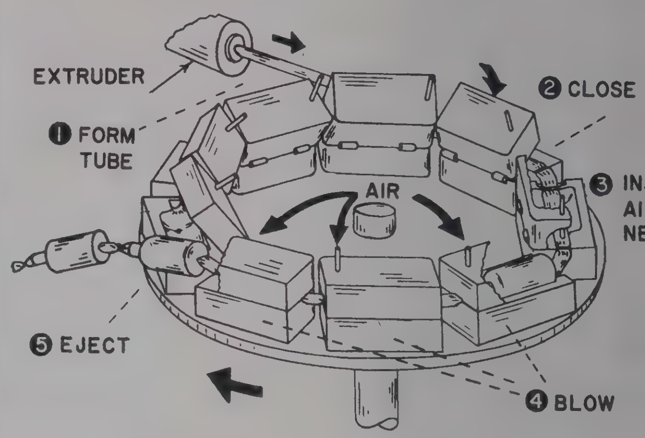


FIG. 3 IN-PLACE PROCESS

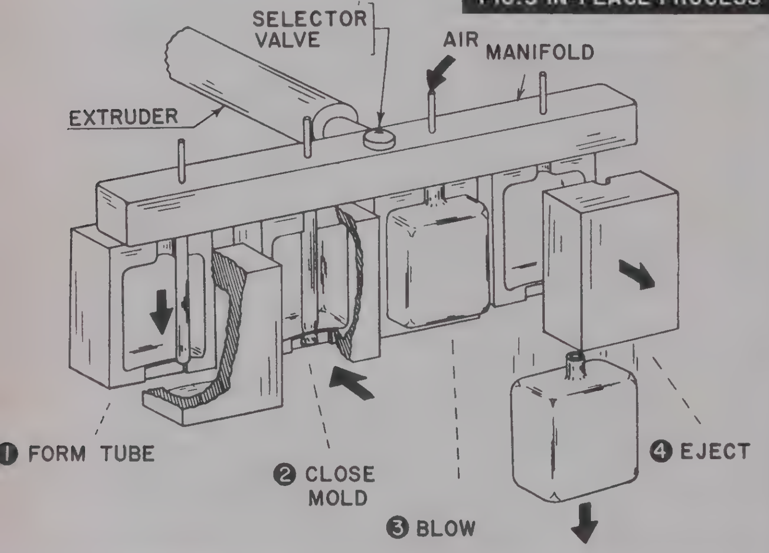


FIG. 4 INJECTION-BLOW PR

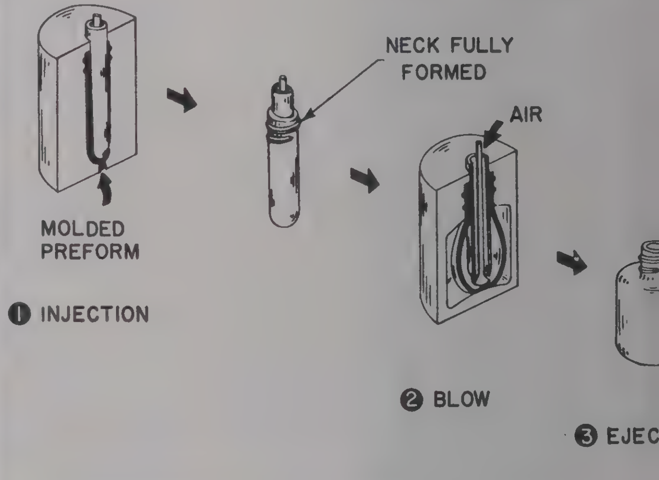
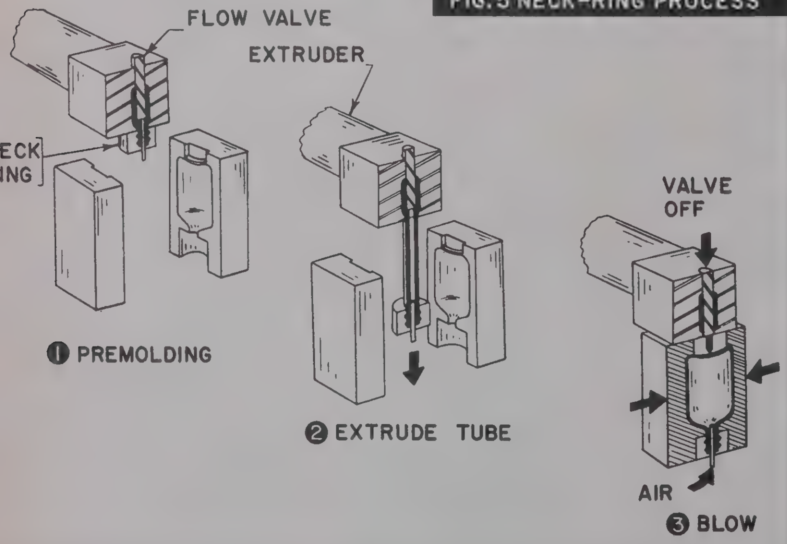


FIG. 5 NECK-RING PROCESS



BASIC METHODS of producing blow-molded containers, as discussed in the text, include the pinch-tube process (diagrammed in Fig. 1), and variations shown in Figs. 2 and 3, both of which also involve pinching of the extruded tube. Figure 4 illustrates a procedure in which closure threads are molded on the open end of a preform, which is then blown to shape. An alternate method to Fig. 4, shown in Fig. 5, involves premolding plus extrusion similar to the vacuum forming molds, but equipped with heat sealing lips around their edges, close onto the extruded sheets from opposite sides. Air pressure applied between the sheets forces them into the cavities and the sheets are heat-sealed together.

Container design

While many designs of containers can be blow molded by each of the three basic methods described above, the machine ultimately chosen for a particular product is determined predominantly by the requirements of the container.

A cylindrical bottle lends itself most readily to blow molding. As the preformed plastic tube is blown, it thins in proportion to the distance it is moved. This results in a wall varying slightly in thickness from the top of the container to the bottom, but uniform around its circumference.

However, cylindrical shapes were not found satisfactory from an aesthetic viewpoint for many products, such as cosmetics, and much work has been done toward the blowing of other shapes. Bottles are presently being blown having a thickness-to-width ratio of up to 3:1.

One of the deficiencies of the method of blowing bottles whereby an open-ended tube is extruded and blown is that the thickness of the tubing cannot be varied lengthwise beyond a limited practical point.

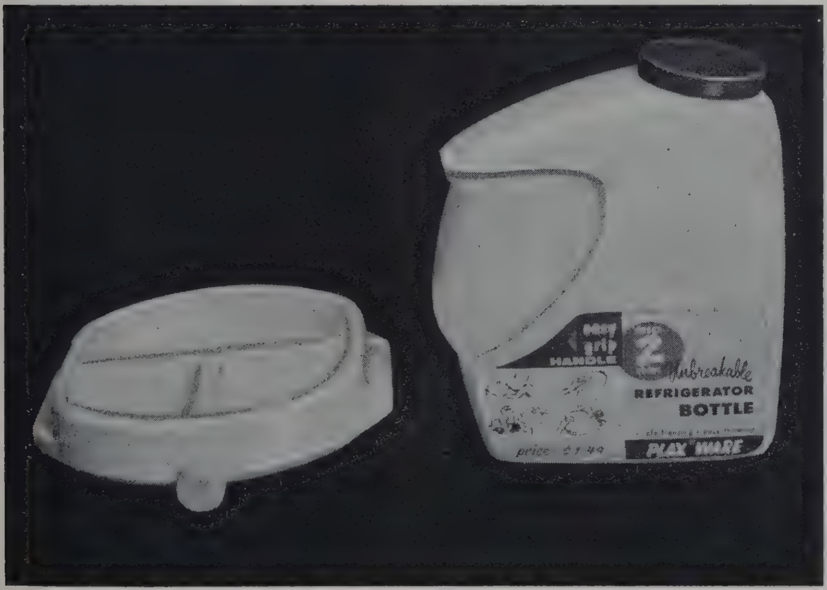
Thin-wall containers now being developed sometimes suffer because sufficient stock may not be provided in the neck to allow for reaming (for dispensing plugs, if required), or the thickness may be reduced to a point where the neck becomes weak. Similarly, if a large-mouth container or jar is blown to allow sufficient stock in the neck for rigidity, the remainder of the container has heavier wall sections than necessary, resulting in the excessive use of raw material. In such cases, premolding of the neck may be the answer.

Other containers, such as the baby dish in Fig. 6, have width-to-thickness ratios substantially above 3:1. They are produced by the flat-sheet method to reduce wall-thickness variations to a minimum. This method is also used to make containers having off-center necks or openings; the refrigerator bottle also shown in Fig. 6 is an example. The location of the neck or opening is not restricted in the flat-sheet method of manufacture.

Mold design

After a container has been designed, a hob is required as a pattern for machining or casting blow molds. If the cavities in the molds are to be machined, the hob is dimensioned to the required size. If the cavities are to be cast, a shrink factor must be applied to the hob dimensions.

FIG. 6: Blown containers of almost any shape can be produced from two flat sheets heat sealed together and blown in a suitable mold



Economies of manufacture and uniformity of cavities have led to the acceptance of cast molds in the blow molding industry on an almost universal basis.

The large majority of blown bottles are decorated by either screen printing, hot stamping, or offset printing. Irregular shapes are screen printed or hot stamped, and the uniformity of the printing surface is critical from cavity to cavity to avoid excess scrap. This problem is reduced to a minimum when using cast molds because all cavities are cast from a common hob.

Since the plastic tubing is blown into the cavities at an elevated temperature and cooled to room temperature, shrinkage takes place as it cools and must be provided for to produce a blown container of the proper capacity. Bottles decorated by screen or offset printing are dried at elevated temperatures. Since this drying causes a further shrinkage, a second corrective factor is applied to account for it.

A third correction is applied to irregularly shaped containers having flat panels that tend to sink inward as the bottle cools.

Spray tubes and plugs

Also to be considered in the design of a successful blow molded package is the spray plug and the proper selection of spray tubing. Spray plugs are designed with an interbore sized for inserting the spray tubing, the other end of which extends down into the liquid of the container. One or more keyways are molded into the bore to provide an air passage along the side of the tubing into an atomizing chamber immediately above the tubing outlet. Squeezing of the bottle forces air up the keyway and fluid up through the spray tubing into the atomizing chamber from which it continues out through an orifice in the form of a spray. A large selection of plugs and spray tubing diameters are available, the inside diameter of the tubing being determined by the viscosity of the material being dispensed and the type of spray desired.

Plastics tooling

By Max Hilrich* and Frank L. Bogart†

While plastics tooling for forming of both metal and plastics components has reached the point where it is "here to stay," it still remains a subject for occasional debate. When controversy over plastics tooling arises, it is usually a result of extravagant or unrealistic claims, of tooling programs undertaken with insufficient planning, or because of erroneous expectations that plastics tools and dies can accomplish "miracles."

Despite these occasional misunderstandings, plastics tooling has found a consistently growing acceptance, largely because when intelligently applied it can show significant savings in equipment investment as well as in time and manpower, with materials savings often an added attraction.

The first big user of plastics tools—the aircraft industry—remains one of the most important. Here the tools help solve a special problem of this industry—the disproportionate cost of time-consuming fabrication of machined tools for producing comparatively limited numbers of parts for any single model.

Other industries in which reliance has been placed on plastics tooling include those in which competition compels manufacturers to make frequent style changes, and put them into effect quickly. Among notable examples are automobiles and appliances. Plastics dies can be altered rapidly and with comparatively small expense. Also, dies made of plastics have often made it possible to reduce the number of operations required to make complicated parts. And plastics dies have become virtually commonplace for the short runs of prototype parts and for limited runs in actual production.

The first group of resins to be widely used in tooling were the phenolics. Polyester resins came next. Then, the epoxies emerged and now dominate the field. This is evidenced by U. S. Commerce Department estimates that epoxies made up 60% of the plastics used for tooling in 1956. Their share of the market has since grown even more impressively, and is now estimated authoritatively at about 95 per cent.

The low cost and handling ease of phenolic resins cause them to continue in demand for some tooling applications. Preference for epoxy resins is generally based on their superior ability to meet requirements for accuracy, strength, and abrasion resistance. Another advantage of most epoxy compounds is that they do not require a heat cure; polymerization is achieved at room temperature, usually after blending with a catalyst or hardener.

Polyester resins are still sometimes used in combination with fibrous glass and other reinforcing materials in the manufacture of reinforced plastic tools. Epoxy resins have also come to the fore in this area, bringing advantages of low shrinkage, superior bonding and wetting properties, and exceptional stability.

Epoxy resins with high heat resistance have made forming of hot metals more feasible. New alloys of epoxies with metals and glass fibers are opening up new spheres for plastics dies for production tooling, partly because of their higher strengths and resistance to surface wear, and partly because they lend themselves to new techniques of using heat and pressure for mass casting.

Production molds of plastics with improved heat transfer capabilities are expected to find increasingly wider use in plastics forming procedure and especially in injection molding.

In general, when a plastics tooling application is fairly critical, with relatively rigorous performance requirements, epoxy resins tend to be chosen as the most suitable tooling materials.

In some instances, it proves worthwhile to use combinations of materials in making plastics tools. For example, further reduction of low cost and weight is brought about by casting or laminating a tough epoxy surface over a cast phenolic or phenolic foam core. Fillers are also added to tooling resins to boost special properties such as resilience or wear resistance, or are used as extenders for increased economy in materials costs.

Final selection of the resin for any given tooling application is dictated by an evaluation of the specific requirements involved. Relevant factors include: material to be formed; number of parts needed; allowable dimensional tolerances; and heat and stress to which the tool will be exposed. When more than one resin will meet all the requirements, cost obviously becomes the decisive factor.

Advantages and limitations

Since highly complex tools are extremely difficult to machine, advantages of plastics tools over metal tools are often most apparent when compound contours are involved.

Savings due to the simpler and faster fabrication of plastics tools are more significant than savings in materials costs. Plastics tools can considerably lower lead time since they are often produced in days, where comparable metal tools might take weeks. Moreover, plastics tools can usually be put to work with minimum delay, since they ordinarily require little or no barbering or finishing.

Minimum disruption of production programs is another benefit of plastics tools, because they can be easily modified or rebuilt by refacing or recasting.

As a general rule, plastics tooling programs can be put into effect at lower initial investment than conventional metal tooling, because of usually smaller equipment requirements. The lighter weight of plastics tools makes them easier to handle than metal tools, sometimes permitting

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*Research Director, The Marblette Corp., 37-31 Thirtieth St., Long Island City, N. Y.
†Sales engineer in charge of the Marblette branch in Detroit.
References were prepared by the editors.

manual rather than mechanical handling. Storage problems are also often reduced or eliminated because of plastics tools' resistance to corrosion.

Extra strength can be added to the plastics tools by using metal inserts in the dies, by using wire flocking and steel and aluminum wools as reinforcements, and by spraying the surface of a mold with metal prior to casting.

While plastics tooling research is continuing and is making great strides, the fact remains that materials and methods have not yet reached the point where plastics can take over completely from metals. In its present phase of evolution, plastics tooling should be viewed as an adjunct to, rather than a replacement for, conventional metal tooling for most practical production purposes.

Fabrication methods

The basic techniques for producing plastics tools and dies are casting, laminating, and splining, either alone or in combination, with variations which stem in one way or another from these procedures.

Tooling resins, either unfilled or filled, are furnished, in most cases, as liquids with viscosity varying according to the formulation. They can be stored in unopened containers for long shelf life. Before use, the resin is blended with a suitable hardener, customarily provided by the resin supplier. Mixing may be done manually, but mechanical means are generally preferable. Pot life of resin-catalyst mixtures varies greatly from one material to another so that materials suppliers ordinarily offer instructions on how soon the mix must be used. Some of the newer resins are formulated for long pot life, with correspondingly greater leeway in processing time.

For casting, the mixture of resin and catalyst is poured directly against a model or a mold made from a model. A parting agent is used to make it easy to separate the hardened plastic tool from the form whose shape it reproduces.

If metal inserts are to be used, they can be set in place when the tool is cast. An alternative is to wait until polymerization is complete and then fit the insert into a cavity milled into the rigid die.

Laminating normally begins with provision for special surface properties such as smoothness and abrasion resistance, by applying a plastic gel coat to the prepared form and letting it stand until it becomes tack-free. This coat is then backed up to a predetermined thickness by successive layers of fibrous glass cloth or other suitable fabric which are impregnated by a laminating resin which may be brushed directly onto the reinforcing material.

Reproduction of complex shapes and contours is aided by the availability of thixotropic compounds which will not run off vertical surfaces when applied outside male forms or inside female forms. These include paste-like resins developed for *splining* and *trowelling* uses.

Selection of casting or laminating as the most suitable fabrication method, as well as the decision on whether to employ modifications of basic methods, depends on the tool's end-use requirements. Laminate tools surpass cast tools in tensile and flexural strengths, are usually lighter and more accurate. Cast tools may mean higher materials costs, but these are compensated by savings in time and labor.

Advantages of both methods are often combined by making tools with a cast core and a laminate surface.

Prefabrication steps

Almost any material strong enough for the purpose can be used to make molds for plastic tools, including such flexible materials as vinyl plastisol and silicones. It is probably more common to use a wood master or a laminate or plaster splash taken from the master. Sometimes a metal part is employed as a mold.

Plaster and other porous molds must be thoroughly dried and then sealed. Several coats of a sealant are usually applied, each coat being lightly sanded with 400 grit paper. The final surface is waxed and buffed, and a parting agent applied.

Because casting resins accu-

CAST PHENOLIC vacuum forming dies have excellent dimensional stability, permitting their interchangeable placement on press for multiple runs. (Photos, The Marblette Corp.)

rately reproduce the surface of the mold against which they are cast, any uncorrected imperfections in the mold surface show up as imperfections on the plastic tool. Careful mold preparation is therefore necessary, including such precautions as smoothing down any weaves or wave-like patterns on the mold surface, sanding off blemishes, and filling in hollows.

Metal-forming tools and dies

Metal sheets of varying thicknesses can be formed on plastics tools of many kinds. These include prototype and production draw dies, stretch dies, drop hammer forms, hydroforming and rubber-pad forming dies. Dies for flanging, trimming, restrike, and secondary operations may have plastic locating pads.

Draw dies cast from epoxy resins to exact contours or made of plastic cast over a metal core have been primarily used in developmental work and for drawing of prototype parts. When contour is not a limiting factor, they have sometimes been adapted to short runs of heavy steel, and used to draw larger quantities of panels from thin-gage steel and aluminum.

Plastics draw dies are among the types of tools for which it is not an uncommon technique to use a cast core and a laminate surface.

Stretch dies fabricated from plastics have a glasslike surface that avoids die marks on formed metal parts. Used in standard stretch presses, where a metal sheet is gripped by clamps and pulled over the die by mechanical or hydraulic power, they may have working face areas of well over 100 square feet.

Laminate shells, cross-ribbed for added strength, are sometimes utilized in making stretch dies. It is more usual, however, for a liquid resin to be cast over a cured core of foamed phenolic or other resin. Low-cost cores with a high ratio of strength-to-materials investment have been made by mixing granite chips with the tooling resin.

Drop hammer dies may be made by casting a filled resin inside a laminate for the bottom half of the die, and placing this in a frame to serve as a mold for a resilient epoxy face on the corresponding punch, which has a lead or Kirksite core. Use of a parting agent permits easy separation of the two halves.

Variations in drop hammer design include plastics punches with metal bottom dies, punches with laminated plastics faces over cast bodies, and punches with steel weldments for higher strength. Recently developed rubber-like epoxy resins with high impact resistance have shown up well as a material for drop hammer forms.

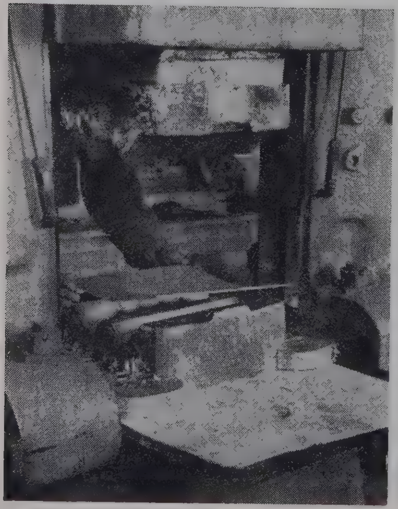
Hand hammer forms of plastics have found a particularly useful place in automotive design programs because they meet the requirements for quickly made and relatively inexpensive tools needed to produce just a few metal parts.

They may be cast solid or made by pouring a casting resin over a foam core. To provide for exceptionally sharp contours, precision-cast inserts of brass and zinc alloy can be used in hand hammer forms. These inserts are set in the mold prior to casting and locked in place by slots or bolt heads protruding into the plastic, or they are put in place during a later stage of the operation by chipping out a section of the form and casting the inserts in position with additional plastic resin.

Epoxies that are curable at room temperature and castable without the uncontrolled exotherm that could ruin both molds and large-mass castings, have made possible plastic dies of almost any size.

Dies weighing over 13,000 lb. have been made by an aircraft manufacturer in a continuous operation requiring approximately one day to pour and one night to set. A low-cost core mix was made by mixing a bulk-mass epoxy casting resin with gravel. A laminate of epoxy and glass cloth was used to surface these tools, the largest of which was about 17 ft. long. Weight savings were better than 50% over cored metal tools. Used on a 350-ton stretch-wrap press, these tools form aluminum sheeting up to ¼ in. thick.

DROP HAMMER DIES with strong, resilient epoxy surfacing withstand many strikes on metal blanks before resurfacing of face is required



Fixtures, jigs, and gages

Since they are fabricated directly from master models or their duplicates, fixtures to check contour flanges and hole locations of parts can be made accurately as well as inexpensively from plastic resins.

Durable, light-weight, yet low-cost fixtures and gages for complicated shapes are made by hand lay-up of epoxy resins and fibrous glass cloth directly onto master models.

Plastics holding forms can be made from an actual part or model by either casting or laminating. Separation is sometimes accomplished by sawing the plastic form into two equal halves.

Similarly, by casting or laminating against an actual part, plastics holding fixtures can be constructed for secondary operations such as trimming, drilling, routing, assembly, plating, welding, etc.

Duplicates and models

Because they provide a fast and inexpensive way of producing copies of actual or projected automobile parts for car manufacturers to send to accessory suppliers and assembly plants for references, duplicate models are popular in the automotive industry.

A usual procedure of producing such duplicates is to apply a gel coat and a laminate over a wooden die model. A framework of tubing or sheet stock is then bonded in place to serve as a base. After setting, the female form is removed from the model. (This may double later on as a die punch spotting rack.) Parting agents are then applied to the female form, and the laminating process is repeated to make as many duplicates as are required.

Casting and laminating resins are also used in making study parts for planning of design, tooling, and assembly operations.

EPOXY RESIN, mixed with quartz aggregate to serve as a cost-saving core for a large metal-forming tool, is leveled off in a plaster mold. Tool's surface will be a laminate of fibrous glass-reinforced epoxy

Foundry applications

Among the reasons for the expanding importance of plastics, especially the epoxies, in the foundry field is their adaptability to simple duplicating techniques. Plastics patterns require less elaborate machining than do metal patterns, have smooth and pit-free surfaces for improved sand release, and reduce costly clean-up time.

Casting, laminating, and trowelling resins have all found places in foundry practice. Some plastics formulations wear well under slinger operation.

Plastics are also being adopted to coat wooden patterns and in foundry repair work to patch worn spots in patterns and metal core boxes. Carvable epoxy resins with superior dimensional stability are expected to foster increasing applications for plastics in fabricating relatively inexpensive, sturdy patterns.

Plastics with special properties such as heat resistance and high strength have served to fabricate core driers used in dielectric baking.

Plastic tools for plastics

Another important sphere for plastics tooling, apart from metal forming, lies in plastics fabricating and molding.

Thermoforming utilizes plastics tools for shaping thermoplastic films and sheets under heat and pressure. Vacuum and drape forming dies can be produced faster and less expensively from plastics than those machined in metal. They are dimensionally stable, so they can be used interchangeably on the press platen for multiple forming, and they also aid mass production by lending themselves to simple revision and repair with minimum downtime. Faithfully reproducing even intricate detail, they provide the close register which is needed when preprinted sheets are being formed.

One-piece bathtubs and, even more notably, huge sectionalized prefabricated home swimming pools are turned out on plastics molds. Other large and small reinforced plastics products and parts are made by vacuum-bag molding and other techniques on cast and laminated epoxy production molds.

For low-pressure molding of plastics components, plastics matched dies are used. Plastics tools have been used for forming crash helmets and for foamed plastics parts such as automobile cushioning and crash pads. Plastics pattern duplicates speed up mass production of products manufactured by latex dipping.

With heat and pressure and by methods sometimes employing a vacuum and sometimes not, cast and laminated plastics tools are used to shape precut and preheated acrylic sheets. Among acrylic objects so made are aircraft windows and canopies, astrodomes, airfield landing light covers, and large advertising signs and displays.

Plastics injection molds based on resins with superior heat transfer properties have not yet quite proved their utility. Belief in their practicality is growing, however, and both materials suppliers and molders are presently involved in production-testing the new resins.

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For further information on the materials used in tooling, consult the Subject Index, and the Directory Index, p. 1078.

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Casting plastics

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CASTING ACRYLICS

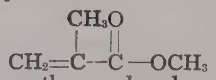
By John O. Beattie*

Cast methyl methacrylate sheets have excellent optical properties[1] because their surfaces reproduce exactly the polished surfaces of the glass molds in which they are cast. Other properties—tensile and impact strength, surface hardness, and thermal and electrical coefficients—compare favorably with those of molded sheets.

Casting-grade methyl methacrylate monomer is a water-white liquid which has the following physical properties:

Specific gravity	@ 25° C.	0.940
Viscosity	@ 25° C.	0.56 cp.
Refractive index	n_D^{25}	1.4118
Boiling point	@ 760 mm.	100-101° C.

The chemical formula of methyl methacrylate is



$$CH_2{=}C(CH_3){-}C({=}O){-}OCH_3$$

and since the molecule contains only one active group, methyl methacrylate polymerizes in linear chains to yield thermoplastic sheets.

As received from the manufacturer, methyl methacrylate monomer contains 20 to 60 p.p.m. of hydroquinone inhibitor. In order to obtain maximum clarity. it is necessary to reduce the amount of the inhibitor to less than one part per million. This cannot be accomplished by ordinary distillation, since the hydroquinone itself is somewhat volatile. A carefully designed fractionating column is required.

Uninhibited methyl methacrylate monomer can be stored for some time if it is refrigerated at around 4° C., but it is best not to accumulate large quantities once the inhibitor is removed.

Casting molds

Molds for casting acrylic sheet are made up of two sheets of selected plate glass, free of scratches and other surface imperfections, or tempered glass (Herculite, Tuf-flex). Tempered glass has the advantage of great strength and resistance to thermal shock, though it is by no means as unbreakable as might be supposed before one has actually handled it.

The two plates of glass, carefully cleaned and dried, are placed face to face and spaced the required distance apart by means of a "gasket" which can be an extruded elastomeric material such as plasticized PVC, or a solid material such as aluminum or steel covered with paper and cellophane tape. Since, however, all monomers undergo considerable shrinkage as they polymerize, use of a solid gasket material requires that the gasket be removed during cure to permit the glass plates to come together and allow for the shrinkage.

The mold, or cell, composed of the two plates of glass separated by the gasket, is clamped together, with one corner left open for introduction of the resin monomer. The clamped mold is then laid in an inclined position for filling.

Pouring the resin

The mold is filled by pouring the resin through a specially designed funnel into the corner opening. Since the plates of a glass mold of any size are quite flexible, it is necessary to introduce exactly the correct weight of resin to get a finished sheet of uniform thickness. Filling the mold to the top would cause the glass to bow out under the hydrostatic pressure of the liquid, and would yield a sheet considerably thicker at the center than at the edges.

The mold having been charged, the opening in the gasket is closed and the mold lowered to the horizontal position. The operator taps the mold to spread the charge and the mold is transferred to a rack and placed in an oven where the resin is cured. The curing temperature in general is between 45 and 70° C. In many cases, a single fixed curing temperature is not satisfactory; if it is necessary to change the temperature during the cycle, a suitable time-temperature control must be installed on the curing oven.

Curing time

The time required to produce a full cure in the mold depends not only on the temperature, but also on the catalyst being used, and on the sheet thickness. Acrylic casting resins evolve heat very suddenly during the polymerization; it is just as much the function of the oven to remove this heat as it is for it to provide the temperature required to start the reaction. Oven requirements are discussed below under "Rate of exotherm."

A possible method of absorbing exothermic heat, in the case of methyl methacrylate, is to mix powdered polymer with monomer to produce the casting sirup.[2] The exothermic heat given off by the monomer is almost counterbalanced by the heat of solution as the polymer dissolves in the monomer. It is claimed that thick methyl methacrylate castings can be produced in this manner and that very little exothermic heat is given off.

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*President, Polycast Corp., 69 Southfield Ave., Stamford, Conn.

[1] The term "optical properties" is a catch-all which includes such properties as transmittance of visible and ultra-violet light, haze, angular deviation, and minor defects. If the sheet is to be accepted for aircraft applications it must meet the rigorous requirements of MIL-P-5425A. A ¼-in. sheet, for example, must have 90% transmission of visible light but must not transmit more than 5% of incident UV in the 290- to 30-mμ range. Its haze value must be less than 3% and it cannot average more than one minor defect for each 4 sq. ft. A minor defect is a small bubble, a scratch, or an imbedded particle. It must not deflect light more than 7 min. of angle from a perfect straight-line path. A 7-min. deflection would cause an object 1 mile distant to appear 10 ft. out of place!

References were prepared by the editors.

[2] U. S. Patent 2,468,094.

For acrylic sheets up to ⅛ in. in thickness, curing time can be held to approximately 16 hr., but thicker sheets require more time, since it take much longer to remove the exothermic heat from a thick piece than from a thin one. In the case of 1-in. and thicker slabs, curing time may be as much as a week.

After curing is complete, the molds are withdrawn from the oven and cooled, the clamps and the gasket are removed, and the glass plates are separated from the now-solid plastic sheet. The plastic surfaces, faithful reproductions of the polished glass surfaces of the mold, are optically clear and ready for use without further processing. Usually, the plastic sheets are masked prior to shipment. Masking consists of applying paper coated with pressure-sensitive adhesive to both sides of the plastic sheet. A sheet so protected can be fabricated without risk of marring the mirror-smooth surfaces.

After the plastic sheets are removed from the molds, the glass plates go back to the cleaning and assembly operations, and the cycle is repeated. The plates of glass can be used hundreds of times if they are properly cared for, making the mold cost per cast sheet very low.

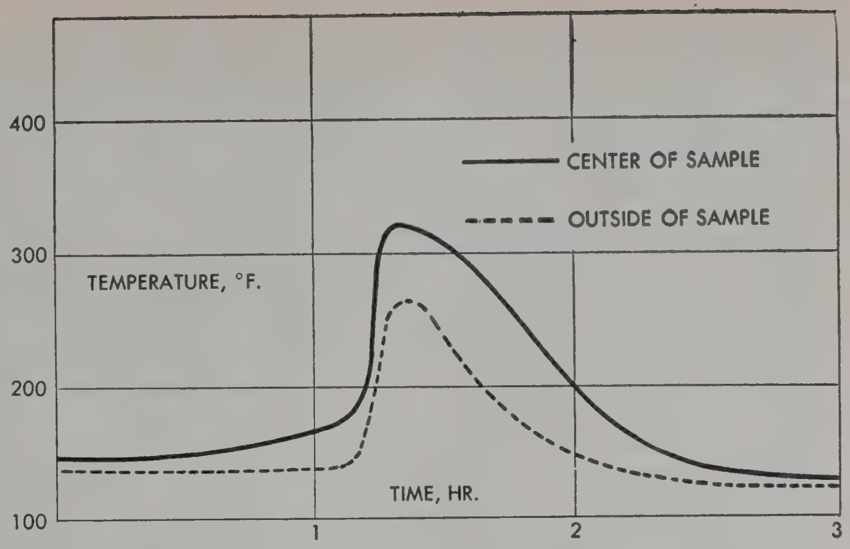


FIG. 1: Typical curing reaction exotherm curves for cast methyl methacrylate. Test sample was a 2-in. diameter cylinder cast in a glass jar immersed in water at 50° C. The "outside" temperature was measured by a thermocouple placed at the resin-glass interface

Shrinkage in the mold

As already mentioned, monomers shrink during polymerization; this shrinkage must be allowed for in the design of molds. In acrylics, it ranges from 15 to 21% and must be taken up by allowing the two glass plates to come closer together during the curing process. If they cannot come together, the sheet will separate from the plates and will be spoiled.

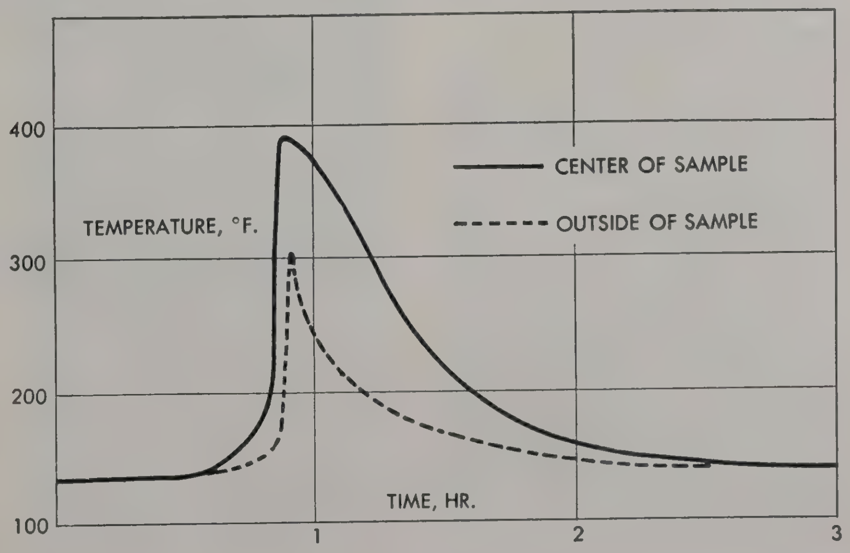
The material naturally seeks to shrink equally in all directions. In the early stages this is possible because the sirup has a relatively low viscosity and flows readily under the stresses set up by volume changes. Later, however, the viscosity becomes very high and at the same time the sheet adheres to the mold plates. Movement in the planes parallel to the plates is severely restricted, so all cast sheets end up with cured-in stresses. These stresses can be alleviated, or at least greatly reduced, by annealing the cast sheet after it is out of the mold. During this procedure the sheets shrink about another 2% and the cured-in stresses are almost completely relieved.

The annealing or shrinking of methyl methacrylate sheets is quite an art, since even slight variation in conditions will produce out-of-flatness or incomplete annealing. Localized optical flaws appear in shrinking which are invisible as the sheets come out of the mold. The would-be manufacturer of cast methyl methacrylate sheet would do well to examine this part of the process most carefully.

Prepolymerization

Another way of reducing the bad effects of shrinkage in the mold is to reduce shrinkage. To this end, the monomer is prepolymerized to a "casting sirup." The use of such a sirup not

FIG. 2: Temperature-time curves for methyl methacrylate copolymerized with methacrylic anhydride. Temperature rose much higher than with pure methacrylate (see Fig. 1, above), although same conditions were obtained, and rate of rise at surge was almost twice as fast



only lessens the polymerization shrinkage in the mold (because some polymerization shrinkage has already taken place outside of the mold), but also offers three other advantages: 1) curing time is reduced; 2) less exothermic heat is evolved during the cure; and 3) the sirup is less likely to leak from the mold.

To prepolymerize methyl methacrylate monomer, the uninhibited monomer (which is a clear, colorless liquid of about the same viscosity as water) is heated in the presence of a catalyst, whereupon it begins to polymerize, gradually becoming more and more viscous until it reaches the consistency of molasses (in June, not January!).

One technique for performing this operation is to heat the material, with a small amount of azo catalyst added, in batches of about 150 lb. in steam-jacketed kettles. During the heating period, the material is mechanically agitated.

Suitable catalysts include benzoyl peroxide, t-butyl perbenzoate, lauroyl peroxide, isopropyl percarbonate, and other similar types. A proprietary catalyst, azoisobutyronitrile,[3] has been suggested for this purpose.

Thickening of methyl methacrylate monomer to a sirup requires careful control, particularly during the cooling phase. With inadequate cooling facilities, the contents of the kettle may heat up beyond their boiling point, causing the vapors of methyl methacrylate to boil out of the kettle, and creating a serious fire hazard.

Rate of exotherm

Figure 1, p. 729, shows graphs of temperature *versus* time during cure of a cylindrical methyl methacrylate casting 2 in. in diameter. For the first part of the cycle, virtually no heat is given off. At a crucial stage, the viscous liquid suddenly becomes an undercured solid, and at this point practically all of the heat of polymerization is liberated. An ordinary curing oven, which would be satisfactory for other purposes, cannot remove fast enough the big slug of heat which is evolved with almost explosive rapidity. If the sheet is a little too thick for the oven to handle, or the catalyst concentration is a little too high, the sudden burst of heat begins to boil the monomer and large bubbles form between the glass plates. The internal pressure mounts fast and the costly glass molds are likely to shatter.

Special care must be taken to remove this heat. Since the amount of heat given off is proportional to the amount of material in the oven, it is the large batches of material and the thicker sheets that are the most difficult to keep under control. Unfortunately, loss of control is most costly when control is hardest to maintain—when the oven is running near its capacity both in molds and in resin. In curing methyl methacrylate, therefore, air velocities and air turnover in the oven must be as high as possible in order that the heat given off at the critical point of the curing cycle may be quickly removed. As an extra safeguard, the oven should have an external vent so that cold air can be brought in as needed.

Since water is a much better heat-transfer medium than air, an extra degree of control is gained by curing thicker sheets, e.g., ½ in. or over, in a water bath. It is only necessary to keep the molds in the water bath until the resin has safely passed the critical point. After this, the cure may be completed in air.

Methyl methacrylate can be copolymerized with a number of other monomers. It copolymerizes readily with most of the available acrylate and methacrylate esters, as well as with styrene and vinyl acetate. Copolymerization with cross-linking materials such as CR-39, diallyl diglycolate, diallyl maleate, etc., yields infusible polymers and properties intermediate between those of the cast pure resins Some of these copolymers are valuable commercially because of their increased solvent and craze resistance, though this is obtained at the expense of formability. In some cases, such as the copolymerization of methyl methacrylate with methacrylic anhydride, the problem of exothermic heat is greatly aggravated, so that the difficulty of safely casting some of these materials becomes very great. The temperature-time graph for the curing of a 2-in. cylinder of this copolymer is shown in Fig. 2, p. 729. Note how much higher the peaks are than in Fig. 1, p. 729, for methyl methacrylate alone. Peak slopes in Fig. 2 are also steeper—rate of heat-up is about 1.5 times as fast.

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CAST AND CASTING THERMOSETS

By Max Hilrich*

Because rather fine distinctions occur in defining commercially available cast thermosets and thermosetting casting compounds, a certain amount of overlapping in terminology is inevitable.

Thus, what are called cast plastics are liquids at some stage in their processing, and may sometimes be the same formulations as casting resins furnished in liquid form by the materials supplier. This discussion will separately consider as cast resins finished castings of various shapes which are available for fabrication into a diversity of industrial parts and products and consumer items.

The casting resins, while bracketed together as liquids, actually range from fairly thin through very viscous liquids, all the way to paste-like and putty-like compounds. Their processing is done by the resin user rather

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*Research Director, The Marblette Corp., 37-31 Thirtieth St., Long Island City 1, N. Y.

References were prepared by the editors.

BUBBLE-FREE EPOXY castings are made with a new crystal-clear material simply by pouring the resin-hardener blend into a mold (left); no vacuum pumping or other special procedures are necessary. The cast parts, after hardening, are readily separated (right) from the mold, which was pretreated with a release agent. (Photos, Marblette)

than the supplier, primarily by casting but also by related procedures such as laminating, splining, and trowelling. They are used to make tools, dies, and fixtures for forming metals and plastics; as paints and varnishes; as adhesives to create durable bonds, often in instances where welding or soldering are impracticable; as impregnating and potting materials for insulating and safeguarding electronic and electrical apparatus; and as splining compounds for repairing plastics, metals, wood, and ceramics.

Combined with fibrous glass and other reinforcements, liquid thermosets are used to make strong plastics parts and products. Formulations may be standard or "customized"; they may be furnished unfilled or filled with metals or alloys; they are used either in their original form or may be combined by the resin user with fillers as extenders or to increase certain properties.

Many special forms of these resins exist. There are foaming thermosets which readily form rigid and easily machineable foams used for insulation and flotation, and often as cores for plastics tools to reduce weight and cost. Some resins have rubber-like characteristics when cast; others cure to a combination of rigidity and resiliency. One comparatively new compound is carvable with hand tools after casting; another provides crystal-clear castings; many have been improved to give higher heat resistance, greater impact strength, and resistance to heavy duty and wear.

Most of the special-property casting resins are in the epoxy family (see p. 89) which have become the most widely used of the liquid thermosets because of their versatility and broad range of characteristics. At the same time, phenolic and polyester casting resins are in demand for applications where their properties or cost best serve the end use.

PRODUCTION molds for cast phenolics consist of lead shells made by dipping steel arbors (mandrels) into molten lead, then cooling and stripping. Thousands of standard master mandrels are available in a wide range of sizes and shapes, and special molds can be made to the customer's specifications

Phenolic castings

Cast phenolics come in a wide choice of shapes, such as tubes, rods, sheets, slabs, and cylinders; special shapes can be made to specification at low mold cost. During processing, dyes and mottles may be added to achieve special colors and effects. Casting is done in lead molds either made to order for special shapes or constructed from any of thousands of steel arbors used as standard master patterns. Polymerization usually is accomplished by an oven cure.

Finishing of cast phenolics ordinarily involves only flash removal, cutting of any required openings which cannot easily be formed by casting, and final ashing or polishing.

Cast phenolics are dimensionally stable, resistant to combustion, hard and rigid, with high tensile, impact, and compressive strengths. They do not peel or chip, and have good resistance to acids, fungi, and heat. Visual appeal is among the reasons for their popularity. They can be obtained in varying degrees of translucency or opacity; in colors from pastels to dark tones; and with special effects simulating amber, jade, ivory, coral, onyx, tortoise shell, and quartz, as well as precious and

CAST PHENOLIC BEADS, earrings, and other costume jewelry in a variety of color and effects are fabricated from stock rods and tubes. (Photo, Marblette)

semiprecious gems and minerals.

Because of low mold cost, cast phenolics have a definite place in product development. They also lend themselves both to specialty production of items where volume potentials may not warrant high equipment outlays, and to quality production of items with visual attractiveness not easily matched by other materials.

Applications of cast phenolics range from demanding ones in national defense, such as for missile components, through fabrication of industrial parts, such as machine housings, to consumer product manufacture and even do-it-yourself uses by hobbyists. Items for which they are widely accepted include handles for cutlery, tools, instruments, appliances, utensils, umbrellas, and fishing rods; costume jewelry; decorative buttons; drawer pulls; bases for trophies, statuettes, and television antennae; cabinets and cases; brush backs; cosmetic bottle tops; poker chips, dice, dominoes, and tiles for word games; ash trays; cigarette and cigar holders and lighters; book ends; paperweights; jewel boxes.

Casting resins

Phenolic casting resins, when stored in unopened containers in cold rooms, have a long shelf life. To use, they are brought to normal room temperature, blended with a chemically active hardener, and poured into molds of various materials which have been pretreated with release agents. Solidification may take place at room temperature or under heat. Polymerization is usually attained by an oven cure with controlled heat applied for a period ranging from a few hours to several days, depending on the formulation and the properties desired in the casting.

Polyesters are usually specially formulated for particular casting requirements. After being poured into a mold, they are generally baked, with air contact excluded during cure to avoid surface softness. Some polyester resins are catalyzed to cure without heat.

Epoxies are usually supplied with a hardening agent. After mixture with the hardener in proper proportions by weight or volume, the resin is poured into a mold, the surfaces of which have been sealed and treated with a release agent. The mixing procedure is often simplified by the growing trend among materials suppliers to prepackage the requisite amount of hardener with the resin. While some specially critical needs may dictate a heat cure, it is more customary for epoxy resins to be polymerized at room temperature.

Epoxy castings are strong and rigid, have high dimensional stability and low shrinkage. They resist chipping, cracking, and crazing. Improved epoxy resins now available can be cast for service requiring high heat resistance, such as in tools for forming metals and plastics under elevated temperatures; high density, such as in uses as barriers against radiation; and ability to withstand impact, abrasion, and wear, even under severe-duty conditions.

Tooling resins

While epoxy casting resins are now estimated to represent 95% of the plastics used in tooling, phenolics are also used and, to a lesser degree, polyesters. There are also cases where thermosetting plastics are used in conjunction with metals and other materials in constructing tools and dies for forming both metals and plastics. For a complete discussion of the application of plastics to tooling, see "Plastics Tooling," p. 724.

Potting, coating, adhesion

Thermal insulation, mechanical shock resistance, and dielectric strength are given to electrical and electronic components by thermosetting resins used for potting, impregnating, and encapsulating. These resins, filled and unfilled, are available in hardnesses ranging from rigid to rubber-like resiliency. They may be opaque, translucent, or crystal-clear.

Choice of the resin to use is, of course, dictated by service requirements. While polyesters, have remained important as electronic insulating materials, preference in many cases is leaning toward the epoxies. These withstand chemicals and contaminants, even after immersion in many cases; they protect highly delicate apparatus from shock, pressure, and temperature changes; they can provide a hermetic seal impervious to moisture and resistant to water absorption even when condensation occurs, as under refrigeration. They do not crack under strain or from fatigue. Even when unusual thicknesses are demanded, they can be cured quickly and easily.

Thermosetting resins can be applied to electrical and electronic parts and products by brush coating, varnishing, impregnating, lacquering, or dipping. Single-component epoxy systems now available can give complete protection by means of a single rapid dip. Antennae, coils, windings, diodes, filters, transistors, and other parts are often completely encased in a plastics block cast from a potting resin. Excellent adherence is typical, with no adverse effect on the materials ordinarily used in constructing electronic equipment.

Thermosetting compounds, especially the epoxy resins, are used as coatings to give indoor and outdoor protection to walls, concrete floors, steel and masonry structures, oilfield equipment, machinery, cans, drums, and other hardware. They serve as undercoats for plastics tools, and extend the life of plastics molds and patterns.

Coating resins adhere firmly to many materials, forming a thin but tough coat. They resist the damage that might otherwise be caused on exposure to heat, cold, fumes, fluids, alkalies, moisture, solvents, caustics, and corrosives. Epoxy maintenance paints simplify plant caretaking. Epoxy varnishes protect finely grained surfaces, yet do not discolor or obscure attractive detail. Epoxy mortars are finding a place for mixture with aggregates for finishing and resurfacing concrete floors. Metal-baking epoxy varnishes, which set on exposure to heat and do away with the need for a catalyst, resist abrasion and chipping even in corrosive atmospheres and at high temperatures. Other epoxy coatings prevent the development of pits and fissures on metal pattern duplicates used for repeated immersion in hot latex. A new development is the use of epoxy caulking compounds in building applications, especially in curtainwall construction.

Adhesives

In addition to high bond strength even under adverse conditions, epoxy adhesives have made great strides because they solve joining problems where conventional adhesives are unsatisfactory. They make it possible to joint dissimilar metals and materials, equalize stress distribution over mated surfaces, and since they can be cured without heat they avoid changes in properties of materials being bonded. Some of the new epoxy adhesives are formulated to resist high temperatures. Metal-filled and other epoxy pastes and putty-like compounds are thixotropic and can be trowelled over vertical surfaces without run-off.

References

See also articles on Epoxy resins, p. 89; Phenolics, p. 128; Polyester resins, p. 146; Adhesive bonding, p. 788; Adhesives Chart, p. 516; and Coatings Chart, p. 524. For sources of casting resins, see specific materials in Directory Index, p. 1078.

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POTTING AND ENCAPSULATION OF ELECTRICAL COMPONENTS

By Harry L. Voorhees

In the electrical field, potting is usually defined as the deep impregnation of capacitors, resistors, inductors, transformers, solenoids, etc.—either singly or in assemblies—with a suitable liquid or liquefiable material which will later cure or harden to provide both mechanical protection and electrical insulation. Encapsulation, on the other hand, means the covering or outer protection components. Some variation exists in the common usage of these terms, potting sometimes implying the use of integral molds (containers, shells, or pots made of metal, thermoplastics, thermosets, or laminates) which become a part of the final product.

However designated, these processes are becoming standard in the various electrical and electronic fields for protecting delicate electrical devices. Potting and encapsulation provide rigid location of sub-units in relation to each other, improved resistance to vibration, protection from damage due to bending, scraping, dropping or tampering, and, in some instances, better heat transfer. They also provide increased resistance of the system to humidity, fungi, and chemical attack, protection against dirt and foreign matter, and better electrical insulation between adjacent components as well as within individual components when deep impregnation is used. As a consequence, the major factors in the failure of electrical devices are being minimized or eliminated by these techniques.

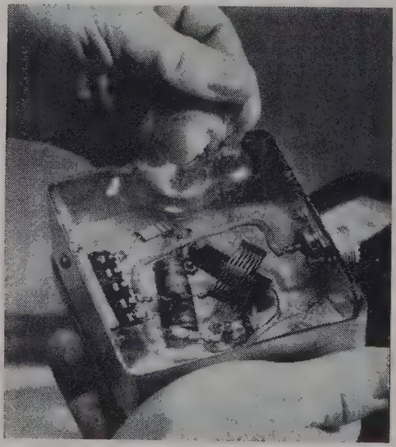
Such materials as wax and bitumen were used for many years as embedding and impregnating media before the advent of casting or potting resins. Vulnerable to local overheating and sometimes apt to degrade electrical performances, these materials have been superseded by suitable thermosetting plastics: phenol-formaldehyde resins, polyesters, silicones, polyurethanes, and epoxy systems.

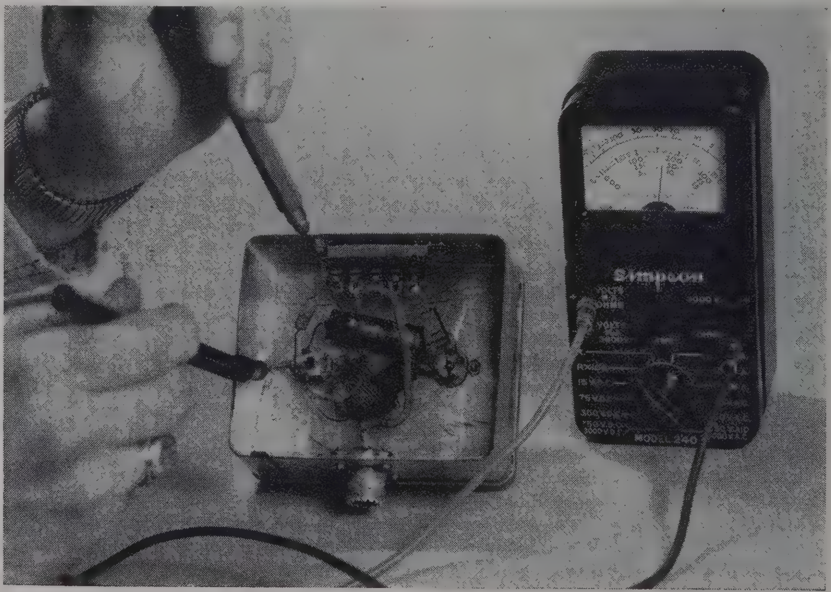
Basic potting resins

The relatively viscous *phenol-formaldehyde resins* harden, when catalyzed, by a condensation polymerization involving the elimination of water. Long slow heat cures under vacuum must be employed to remove condensation byproducts if void-free castings are to be attained, and shrinkage during cure is high. The mechanical and electrical properties of the cured materials are only fair. Perhaps their chief advantage is their low cost.

Polyester potting resins (usually styrene solutions of the esterification condensates of various dihydric alcohols and unsaturated dibasic acids) are catalyzed with organic peroxides to initiate copolymerization of the styrene and resin components by means of a vinyl-type addition reaction. The monomeric styrene present functions not only as a cross-linking agent but also as a diluent to provide viscosities sufficiently low for impregnation of fine structures. Unfortunately, however, increased styrene causes increased shrinkage during cure (up to 10% by volume). This monomer also tends to dissolve wire enamels. Other disadvantages include the poor wetting qualities of these systems, and their tendency to degrade at elevated temperatures.

NEW SILICONE potting compound, known as "dielectric gel," is poured (above) at room temperature after catalyst is added. Cure takes place in 30 min. to 48 hr. at 40 to 150° C. Cured material is transparent, exerts no stresses on potted components, and has a resilient, jelly-like structure. If physically disturbed (below), it "heals" itself. Potted parts can be inspected visually or tested with probes (right). When probes are withdrawn, holes reseal themselves. (Photos, Dow-Corning)

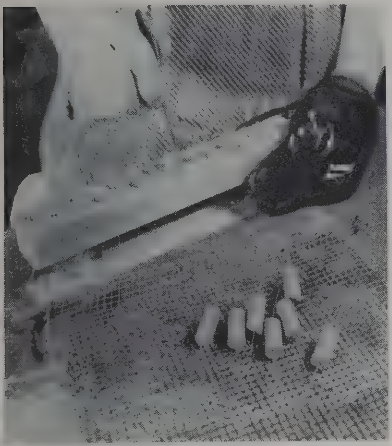




The *silicones* (organopolysiloxanes) include a variety of compounds characterized by a skeleton of alternating silicon and oxygen atoms with various organic groups attached. Depending upon whether they are linear, branched, or cross-linked, silicones may be fluids, elastomers, or thermoset resins. For electrical impregnation, low-molecular-weight, linear, vinyl-containing polysiloxanes are now available. Catalyzed with dicumyl peroxide or ditertiarybutylperoxide, these solventless, low-viscosity, long-pot-life systems cure in a few hours at moderate temperatures into thermosets with good physical and electrical properties. Post-curing for a few more hours at the maximum operating temperature prepares the material for continuous use at elevated temperatures with good retention of electrical properties. For embedment, silicone rubbers, putties, and tapes are available, as well as low-density rigid and flexible silicone foams. Room temperature setting foam-in-place formulations are available which will produce uniform, small-celled, flame-retardant, low-water-absorption foams capable of being used continuously at high temperatures. Expansion and curing is initiated by stirring in a catalyst and only simple equipment is necessary.

In general, however, silicones are expensive and difficult to process; consequently their use has been limited to Class H conditions and jobs that could not be done with cheaper or more convenient materials. Their disadvantages include long cures, poor solvent resistance, and poor adhesion to surfaces. On the credit side are their good ozone resistance, slow combustion rate, high thermal conductivity, good electrical properties, and good performance at both high and low temperatures.

The *polyurethanes* are a class of varied and versatile new materials produced by the reaction of diisocyanates, usually tolylene diisocyanate, with compounds containing active hydrogens. These compounds include those bearing hydroxyl, amine, or carboxyl groups. Formulations incorporating hydroxyl-terminated polyesters, simple glycols, hydroxyl bearing polyethers, castor oil, drying oils, and others are available. The number and distribution of functional groups present and the extent to which such reactants are linear or branched determines whether flexible, semirigid, or rigid polyurethanes are obtained. Isocyanates also react with water to produce amines, which can later copolymerize, and carbon dioxide gas; hence, these materials can act as their own blowing agents. "One-shot" or "prepolymer" foam-in-place formulations are available which will make rigid or flexible urethane foams at room temperature. Possessed of toughness, ability to wet and adhere to surfaces, low shrinkage, low viscosity, and good electrical properties, polyurethanes afford protection against abrasion water, solvents, low-temperature cracking, vibration, and acceleration stresses. These interesting polyurethane materials are becoming increasingly useful in potting and encapsulation work.



ENCAPSULATED in epoxy, R.F. inductors meet strict specifications for physical, electrical, and chemical properties. (Photo, Union Carbide Plastics)

The *epoxy resins* in general use are condensation products of epichlorohydrin with bisphenol-A or, less frequently, with other poly-hydroxyl-bearing aromatic and aliphatic materials. These compounds are available in a series ranging from low-viscosity liquids to high-melting-point solids. They are characterized by the presence of epoxy or oxirane groups and their curing or hardening to thermoset solids depends upon the capacity of this group to react with many different materials. Hardeners or cross-linking agents for epoxies include room-temperature-curing aliphatic polyamines and heat-curing aromatic amines and acid anhydrides. Polymerization of epoxies with them-

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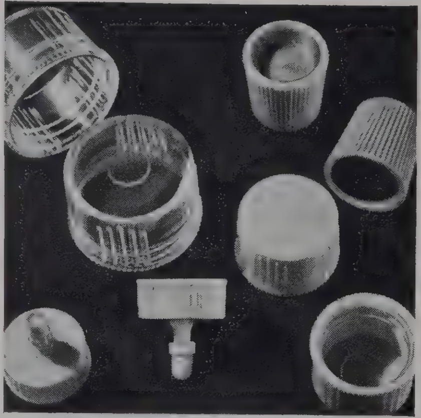

Newark Die molds are used to make a wide variety of screw caps of which these are typical.

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selves or via hydroxyl groups (if present) can be initiated by catalysts such as boron trifluoride complexes, tertiary amines, and free alkalies.

In all cases, addition polymerizations are initiated and no byproducts are formed. Epoxies may be formulated into a variety of rigid, flexible, foaming, or "syntactic" foam systems adaptable to diverse production situations. These materials exhibit low shrinkage during cure and excellent resistance to most solvents, chemicals, and water. Having good wetting properties, they are outstanding adhesives. Because of their good electrical properties, high mechanical strengths, outstanding chemical resistance, and thermal stability, together with their versatility of formulation and ease of handling, epoxy systems have a secure and expanding place in the field of impregnation and encapsulation.

Fillers and flexibilizers

Besides the use of fillers for various purposes (see article on p. 440), basic potting and encapsulation systems can be further formulated by the incorporation of polysulfides, polyamides, or other flexibilizers and plasticizers to produce flexible end products. Such flexible systems are useful in the electrical field to absorb and distribute stresses due to shrinkage during cure or to thermal cycling.

Foam formulations are also available for these purposes and for use in situations where weight is at a premium, as in aircraft applications. All of the basic resin types mentioned can be used in foam formulations either by adding tiny nitrogen-filled phenolic or urea-formaldehyde spheres as a filler to give low-density materials, or by incorporating a chemical blowing agent to achieve a foam structure.

Molds and mold release agents

For proper impregnation and a solid potting job, liquid, long-pot-life, highly adhesive potting formulations are desirable. These necessitate the use of molds of some type, and the long cure schedules associated with such materials require the use of many reuseable molds, if such are employed, for high production rates. An additional complication is the application of mold release agents in order to permit separation of the finished component. In terms of basic cost, usage, and maintenance, molds may represent the most expensive factor in potting and encapsulation operations.

In general, simplicity is the key to cutting costs. Work has been done with internally heated and cooled multicavity molds; modified transfer-type molds have also been designed to produce fully impregnated precision pottings with virtually no shrinkage. Where possible, however, the part to be impregnated should be adapted to simple molding procedures and mold over-design should be avoided. A one-part mold equipped with an ejection pin, for instance, is better than a multipart mold that must be torn down. Especially effective, of course, is the potting of components in integral molds which become part of the finished unit.

Other alternatives to expensive individual metal molds include plastic molds, flexible molds, or low-melting alloy molds made by the "dip" or "spray" method. Epoxy formulations, because of their low shrinkage and rigidity, are among the best of the many plastics that can be used for mold making. Plastisols and rubbers are suitable for flexible molds, but compatibility with the resin systems must be checked. Neoprene rubber molds may be made by pressing a metal pattern into a stack of uncured sheets and curing under heat and pressure; some of the silicone rubbers may be satisfactorily used for molds which will withstand repeated cycling at relatively high curing temperatures. Low-melting-alloy molds can be made by dipping a well-polished male master die into the molten alloy. The alloy loses heat to the master die and solidifies into a shell which is its exact female counterpart. The mold is removed while still warm and the die is cooled again to begin the next cycle. Multipart molds have been successfully made in this way. Complex shapes can be made by using an easily worked and removable substance, i.e., soap or

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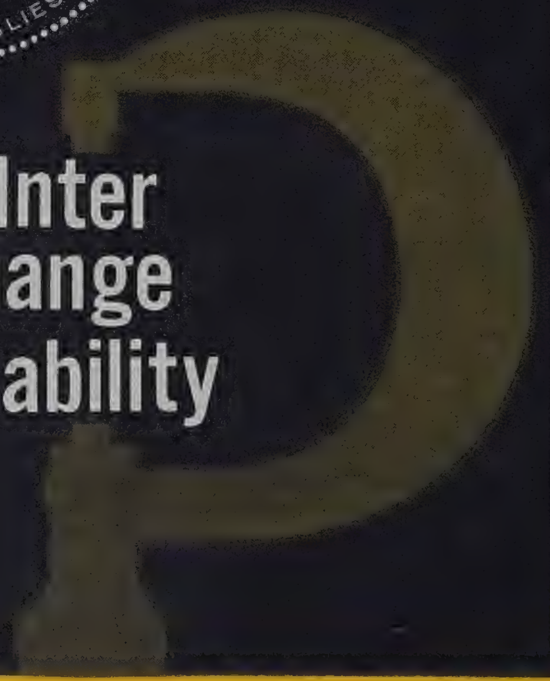

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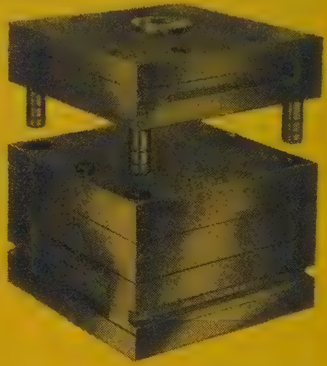

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wax, for the prototype and spraying on the molten alloy. The prototype is melted out, the component is potted and cured, and the alloy is remelted for use again.

Except in the cases of integral and "self-releasing" molds, i.e., molds made of substances which will not permit adhesion of the particular potting compound being used, mold release agents are required. Mold release agents adhere to the mold but present a nonadhering surface to the resin. Paste or wax-type mold releases may require hand polishing if they are used on irregular molds; with liquid release agents, however, dipping or spraying methods may be used. The active diisocyanates react even with silicone greases and oils; hence, paraffin wax must be used to effect release of polyurethanes. Polyester and epoxy systems will be released from surfaces of Teflon, silicones, certain waxes (such as carnauba) and greases, and plasticized vinyl or synthetic rubber.

Techniques and equipment

Components may frequently be successfully potted by heating them in the mold to remove moisture, permitting them to cool, pouring in resin, and allowing an hour or two for penetration before cure and postcure. More sophisticated techniques are sometimes required if bubble-free and void-free castings and complete penetration are to be attained—particularly where dense structures are to be penetrated. In such cases, vacuum may be applied to remove dissolved gases and air bubbles from the resin and air entrapped within the component; pressure may subsequently be applied to force the resin into the less accessible parts of the component and to compress any air bubbles remaining in the resin. Vibration techniques have been employed to control the thickness of resin coatings on small components, to improve their appearance by eliminating bubbles, and to increase filling rates when casting without vacuum. The use of ultrasonic energy for the deep and rapid penetration of coil windings has received attention. Centrifugal pressure has been economically and successfully used to force resin through fine wire coils and continued during cure where parts of critical mechanical and electrical properties were required.

For high-production components, automatic equipment can reduce costs. Vacuum casting units are available, as are units for mixing, metering, and dispensing resin. Mold-stripping fixtures—simple arbor presses or air-activated mechanisms—may be used in conjunction with automatic feeding and positioning equipment for efficient large-volume operation. Tools for cutting off the rough sides of parts (rotary cut-off wheels or diamond-tipped cutting edges for the smooth cutting of abrasive cleaning equipment (spraying fixtures, dipping fixtures, and blasting apparatus) are available. For curing, conveyor-belt ovens provide more uniform heat and more constant cure cycles than batch ovens; with electrically or steam-heated circulating air and mesh or roller-type belts, they cure components evenly.

The potting and encapsulation of electrical components is not a static field. Continued development of new resins, improvements in formulating potting compounds from them, evolution of increasingly efficient handling techniques and equipment, and the proven worth of potting and encapsulation in the manufacture of better electrical devices insure that this field will continue to expand.

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For further information on properties of resins used in potting and encapsulation, consult Subject Index under resin names. For sources of supply of resins, see the Directory Index, p. 1078.

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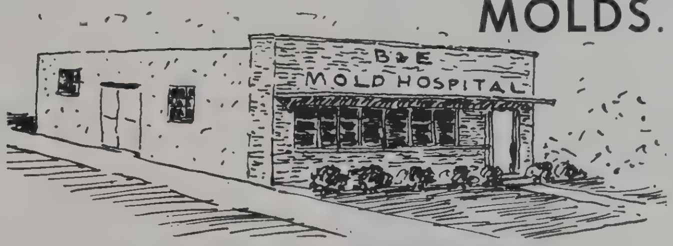

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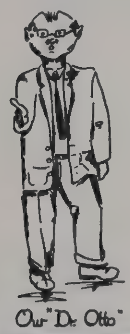

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PLASTISOL MOLDING

By W. J. Kaufman[*]
and David P. Jackson[†]

Plastisols are dispersions of polyvinyl chloride resin in suitable liquid plasticizers. At room temperture, plastisols may vary in consistency from water thin to heavy pastes; at about 350° F. fusion takes place, resulting in a tough, solid mass. Because of this liquid-to-solid conversion without the need for pressure, plastisols are adaptable to simple, economical molding by a wide variety of methods.

Molding advantages

Only lightweight, inexpensive molds are needed for molding. Plastisols are 100% solids and no significant loss in weight occurs during fusion. Molding plastisols are relatively low viscosity liquid compounds that can be pumped, poured, or sucked into a mold, or the mold may be dipped into the liquid. Objects may be molded with thin or thick walls, depending on the molding procedure used.

Plastisols may be formulated to have varied physical and chemical properties. Some of the properties available in almost any combination include:

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[*] Vice pres., Watson-Standard Co., 225 Galveston Ave., Pittsburgh 30, Pa.

[†] Chemical Products Corp., King Philip Rd., East Providence 14, R. I.

References were prepared by the editors.

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Dip molding

Dip molding consists of dipping an external mold into the liquid plastisol, fusing or fluxing, and then stripping the finished article off the mold. Automotive pump diaphragms, spark plug covers, collapsible tubes, thread protectors, boots and toys are a few of the items that may be made on a commerical basis by this technique. The molds, usually solid, are made of cast or machined aluminum, machined brass, steel, or ceramic.

A typical dip molding system includes a conveyorized line passing through a preheat oven, a dipping station, a fusing oven, a cooling station, and a stripping station. The preheat oven is used to heat and mold prior to dipping. Although in certain cases the molds are dipped at room temperature, normally they are preheated to control the thickness of the plastisol deposited on the mold. For most common applications (wall thicknesses of $\frac{1}{16}$ to $\frac{3}{32}$ in.), the mold is heated to approximately 300° F. prior to dipping. For heavier wall thickness the preheat temperature should be higher. The mold is inserted into the liquid plastisol rapidly and then withdrawn at a rate of from 4 to 6 in. per minute. In some cases, the mold is inverted, after withdrawal, to allow redistribution of excess liquid plastisol. The plastisol on the mold is then fused at oven temperatures from 350 to 400° F. The length of

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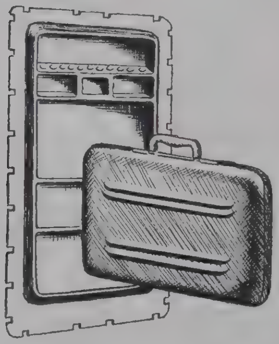

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time in the oven will vary from 5 to 15 minutes. After fusing, the mold is cooled (either by air or a water spray) and the molded piece is stripped from the mold.

Combinations of expanded vinyls and plastisol skin may be adapted to this method of molding, which is of particular interest in the manufacture of such items as boots and gloves because of the insulating qualities of expanded vinyls.

The vinyl skin is formed as outlined above. After the plastisol on the mold surface is cured, the mold is inserted into the plastisol sponge (chemically blown type) bath and then withdrawn. The mold is then usually inverted to allow redistribution of the sponge plastisol and fusion takes place at temperatures of 350 to 400° F.

Thickness of the sponge section may be controlled by two methods: 1) heat of the mold and 2) rate of expansion of the sponge plastisol compound.

Since mold detail is on the interior of the dip molded piece, the part is sometimes turned inside out, as is the case of dip-molded boots. This is usually true also of plastisol-sponge combinations since the insulation is required on the interior of the molded part.

Dip molding lends itself to high rates of production because many individual molds may be dipped at one time. This method also lends itself to practically automatic molding since the molded parts may be automatically removed or stripped from the molds by compressed air, so that a single operator can run a complete production line.

Slush molding

Basic to slush molding is the ability of plastisols to solidify immediately on contact with heat. This feature is exploited by filling a preheated hollow mold with plastisol, allowing the material adjacent to the mold walls to gel, and returning the remainder to the reservoir. The wall thickness of the deposited film is controlled by the temperature to which the mold is preheated and the length of time the plastisol is allowed to dwell in the mold before being dumped.

This process usually uses electroformed copper or fine aluminum sandcast molds. Heat is applied to convert the plastisol to an elastomeric solid; the mold is then cooled for convenient handling while stripping the molded piece.

Most of the production lines using slush molding follow one of two basic systems: single-pour or double-pour. Both are readily adapted to conveyorized lines.

A single-pour system involves a single filling station where the molds are filled by vacuum, gravity, or pressure. If gravity or pressure filling is used, the filled molds are either spun or vibrated to eliminate bubbles at the extremities. After filling, the molds are heated—usually by infra-red or by immersing in hot water—to the temperature necessary to produce the required wall thickness; the mold is then inverted and the still-liquid plastisol drained out. The plastisol lining left in the mold is then fused in an oven at temperatures from 350 to 375° F. Fusing time depends on the size of the molded piece and the wall thickness desired in the finished part. Following the fusing cycle, the mold is cooled, usually by fine water spray.

In the two-pour method, the cold mold is filled, usually by gravity or by pumping, and vibrated to remove bubbles. It is then dumped, leaving a thin film of plastisol on the surface. By filling a cold mold in this manner there is less chance of entrapping air or of gelation over fine details at the extremities.

After dumping and draining, the mold is passed through an infra-red or hot-air oven to fuse or semifuse the first skin. After passing through the first pour oven, the mold is filled a second time, dumped, and allowed to drain. The length of time the mold is in the first oven determines the wall thickness of the final part because the heat of the mold retained from the setting or fusing of the first skin will determine the ultimate thickness of plastisol deposited on the walls of the mold. The mold is then passed through a second oven for final fusing of the plastisol part. The mold is then cooled and stripped in the same manner as in the single-pour system.

Sponge plastisol may be handled similarly when items such as boot socks and toys are manu-

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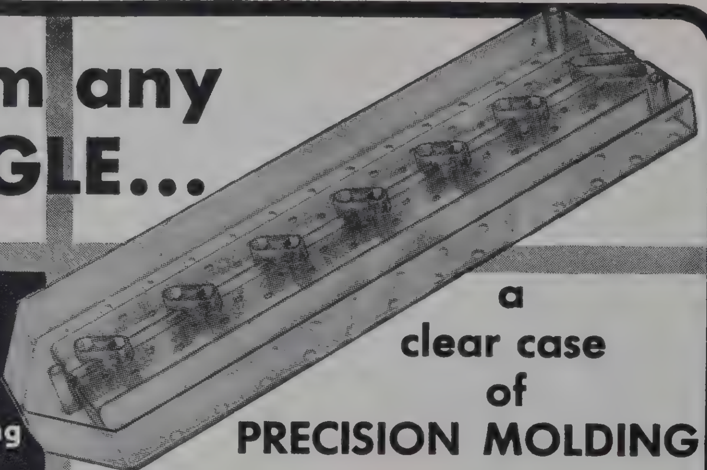

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factured completely of sponge. When a plastisol skin-sponge combination is desired, a two-pour system is used, with sponge vinyl plastisol poured in the second step. This method is used in the production of dolls and doll parts, insulated boots, and electrical component covers.

To point out advantages of the different processes is difficult since they are very similar in nature and the final products in both methods are accepted commercially. However, it is obvious that handling in the single-pour method is at a minimum, whereas in the two-pour method the possibility of air entrapment is reduced to a minimum.

Slush molding has many advantages in the production of open hollow moldings. The process is relatively simple. Parts which show no parting line may be made in a single-piece mold. When the piece is removed from the mold it is finished and, except for decorating, there is no finishing expense. Undercuts present no problem whatsoever and fine detail is easily obtained.

Rotational molding

The rotational casting of plastisols has become increasingly popular, especially for long-run items. The rapidly expanding number of end uses for plastisols molded by this system is due, at least in part, to recent innovations in formulation which make available versions as rigid as 80 on the Shore D scale. Such high hardness is accomplished by compounding acrylic ester type monomers into vinyl dispersions. The use of closed molds in the rotational molding process restricts the evaporation of these acrylic monomers during the initial heating stages, allowing time for the monomers to polymerize to hard, high-molecular-weight polymers.

Rotational molding produces completely enclosed hollow moldings in two-piece molds. A predetermined amount of plastisol is introduced into one half of the mold; the two mold parts are clamped together and then rotated in two planes. This rotation is accompanied by heating either to gel or to fuse the film of plastisol after it has been evenly distributed on the interior walls of the mold.

There are several advantages to rotational molding, namely: weight of molded parts may be accurately controlled; there is less possibility of contamination of the plastisol; the reject rate is lower; there is less scrap; and the operation is much cleaner.

Rotational molding equipment is generally classified as continuous-type or batch-type. Molds used for rotational molding are either electroformed copper or cast aluminum; in some cases, machined aluminum molds are used. Depending on the surface desired on the finished product, the molding surfaces of these molds are left as cast or polished to a high finish. Highly finished molds produce a glossy surface on the finished product, while unpolished surfaces leave a dull or mat finish. The parting line of the molds should be machined after casting so that the mold will close tightly, preventing leakage while the plastisol is in the liquid form and thus reducing objectionable flash on the molded part.

The simplest type of rotation equipment is the batch-type. Basically it consists of a platform which rotates in two dimensions simultaneously and is normally enclosed in an oven for heating the molds while they rotate. The molds are filled outside the oven and clamped on a plate, which is then locked in place on the rotating platform. In most cases the plastisol is fused while in the rotator; however, in some cases, the plastisol is merely gelled or set in this equipment and then removed and fused in a separate fusing oven. The advantage of fusing in a separate oven is a large turnover of molds in the rotator.

The continuous-type of rotational molding equipment consists of a conveyorized system with individual rotational stations which travel on the conveyor. A complete cycle includes automatic volumetric filling of the molds, automatic closing, engagement of rotational gearing, fusion of the plastisol while rotating, cooling of the mold either by water spray or cool air, automatic opening of the mold, and removal of the finished part. This equipment is highly mechanized and necessarily complicated. It is operated with a minimum of labor

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In the rotational equipment described, the rotation in each axis or plane is regular or circular in nature. By the use of irregular motion in each plane, one equipment manufacturer claims that a more even distribution of plastisol in irregular molds may be obtained, and that, by the use of cams, localized desposition may be accurately accomplished. Thus, in the case of a hydrometer bulb or a toilet tank ball valve, one section of the molded part could be of a heavy wall thickness while another portion could be thinner.

This can also be accomplished through ingenuity in mold design wherein the thickness of the molded section is controlled through the thickness of the mold walls in particular areas. Generally speaking, since the heat is transmitted more slowly through a relatively thick mold wall, the molded section in the area would be thinner in relation to other areas of the article. The use of such lopsided molds makes possible intricately shaped moldings of varying thicknesses.

The products manufactured by this process range from toys and novelties such as dolls, toy bowling sets, beach balls, piggy banks, artificial fruit, and flowers, to such functional items as toilet balls, squeeze bulbs, industrial casings, and battery-testing-unit housings. With a good portion of the toy market already realized in this field, the greatest potential now seems to lie in rotational casting of industrial pieces. The outstanding physical and chemical properties of plastisols combined with the wide range of design possibilities in forming by this process certainly indicate the replacement of many tedious fabricating processes using metal, rubber, leather, and ceramics.

Low-pressure injection molding

Plastisols are used in the manufacture of solid castings or solid molded parts, although not as extensively as in the manufacture of hollow molded parts. The simplest process for the manufacture of solid molded parts is merely pumping or pouring plastisol into a cavity until it is filled.

Usually it is necessary to use a covered cavity mold for this process because during the heating or fusing cycle there is some expansion of the plastisol followed by some contraction on cooling. On parts where thick cross-sections are molded, bleeders are necessary to relieve or reduce the pressure on expansion. The time necessary to fuse any given molded part by this method will depend largely on the cross-sectional thickness of the part. A rule of thumb to determine approximate fusing time is that for every ⅛ in. of cross-section, 7 min. of curing time should be allowed at 350 to 375° F. Molded parts with cross-sectional thickness as high as two inches have already been made and marketed.

A more advanced technique for this type of molding might be designated as low-pressure injection molding. Low-pressure pumps of the grease-gun variety can be successfully used to inject the liquid plastisol into a two-piece mold or cavity. Here the molds must be designed with bleeders at the cavity extremities to allow for complete filling. The process is simply to close the mold, pump the plastisol into the mold until it runs out of the bleeders, place the mold in an oven for fusion, remove, cool, open the mold, and take out the finished part.

The molds used for this method are of aluminum, copper, brass or steel, and they may be either sand-cast or machined. As in the rotational molds, the closing surfaces of the two-piece molds must be machined to provide a tight fit and, again, the finish of the molded part depends entirely upon the density, polish, or texture of the mold surface itself. The wall thickness of the metal molds should be kept to a minimum to provide for quick heat transmission, but thick enough for good structural strength to withstand the pressures involved.

For the most part, solid plastisol moldings are made by the batch-process. Conveyorized continuous molding processes are not practical, due usually to the length of time required for fusing. The batch-process is excellent when a limited number of parts are required since the mold cost in

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comparison with that for conventional molds is very small.

Some applications of plastisol parts made by the batch process are seals for ceramic tile, sink and disposal stoppers, advertising display plaques, and novelties.

In-place molding

The outstanding moldability and versatility of plastisols have led to some very significant large-volume applications which can be designated "in-place molding." Most successful use of this type of operation has been in the field of gasketing.

For example, two leading manufacturers of the new dry, pleated paper, automotive air-cleaner have used plastisols to very great advantage in molding end-seal gaskets. These manufacturers were able to replace a several-step process involving precut gaskets and adhesives with a simple, one-step, high-speed molding operation. Incorporated in the air-cleaner are a special corrugated paper as the filtering medium, surrounded by a metal screen for extra support. The air-cleaners are made by placing the filter and support elements in ring-like molds filled with liquid plastisol, and then fusing the plastisol. The operation is repeated for the other end. The fused plastisol not only consolidates each end of the filter into a sealed assembly, but provides, as well, excellent air-tight assembly gaskets.

Flowed-in gaskets are applied in the plant to vitrified sewer pipe by placing specially designed molds over the bell and spigot ends of the pipe length, filling them with plastisol, and fusing it. This new system has replaced the tedious process of joining pipe in the field with such compounds as okum and mortar and has already practically revolutionized the industry. With this new gasket system, pipe can be laid at astonishing speed, even under water. Plastisol in this end use is formulated to a hardness which permits the pipe lengths to be fitted together easily, forming a tight seal. Wiping the gaskets with solvent lubricates the gaskets for joining the pipe and, when it drys, seals the gasket together permanently. One of the outstanding characteristics of plastisol in this end use

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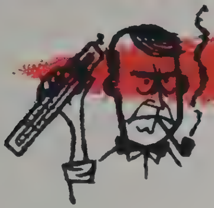

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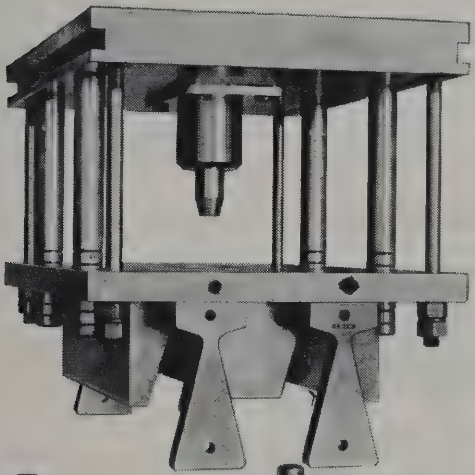
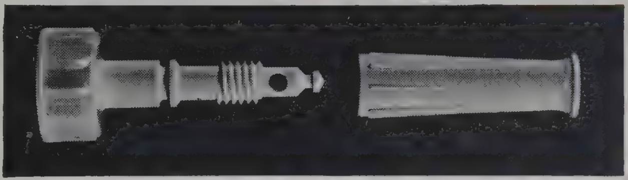
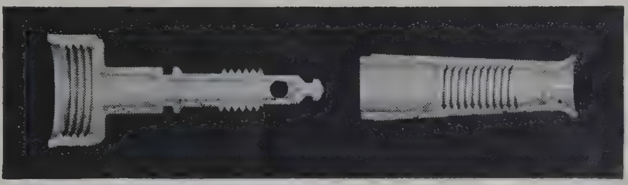
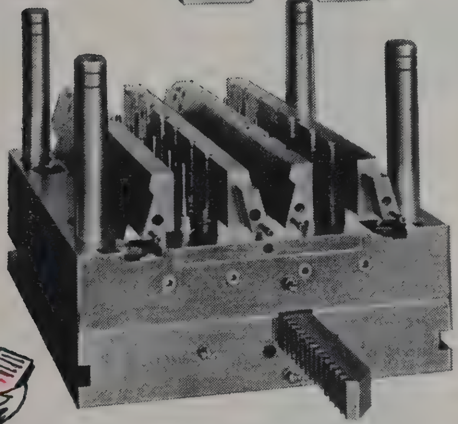




MOLDED PIECE



INTERNAL VIEW



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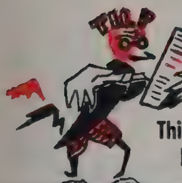

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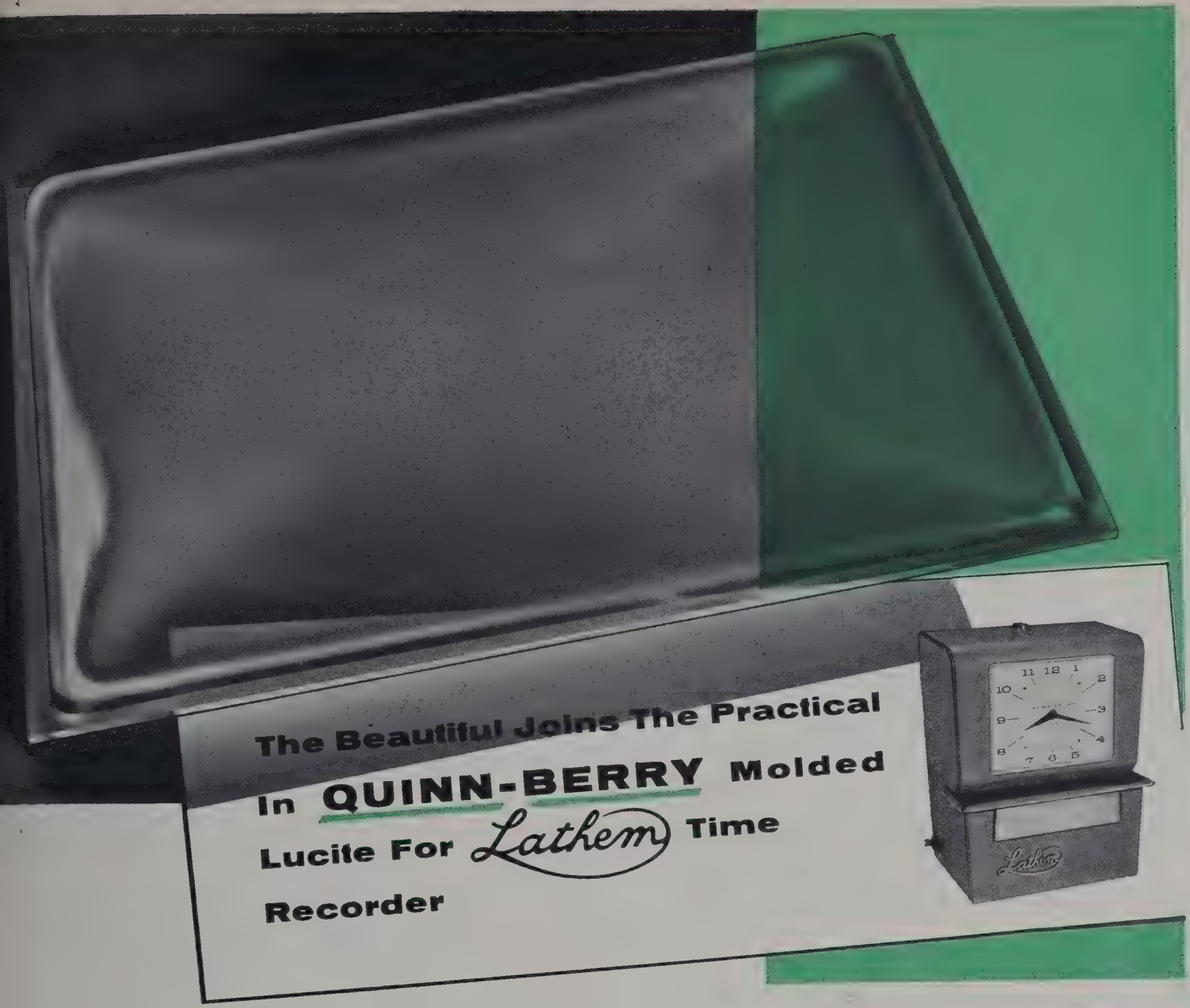
Combined methods

There are occasions, particularly with plastisol skin-sponge vinyl combinations, when the use of two of the above-mentioned methods is advantageous to produce a single product. Such items as arm rests, gaskets, toys, squeeze balls, and electrical packings may be produced with a tough outer skin of vinyl plastisol and a solid interior of expanded vinyl. The skin can be formed by spraying, slush molding, or rotational molding; the interior by casting, low-pressure injection, or rotational molding.

Combination plastisol skin and expanded vinyl products may be divided into two categories: 1) those in which the complete exterior surface is a plastisol skin, as in the case of arm rests, crash pads, toy blocks, squeeze balls, toys, etc., and 2) those in which only part of the surface is a plastisol skin, such as gaskets, packing, chair seats, and others.

For products requiring an exterior surface completely covered with plastisol skin, a combination of rotational molding and low-pressure injection molding may be used. In this case, the skin is molded in the normal rotational method. After curing of the skin, but while the mold is still closed, vinyl sponge or foam is injected into the interior of the mold. In the case of vinyl sponge, the amount injected is predetermined, but with vinyl foam the mold is filled. Then the mold is either placed back in the rotational equipment or into a conventional oven for fusing or expanding the sponge or foam plastisol.

For products having a plastisol skin on only a portion of the exterior surface, several methods may be used. The vinyl plastisol may be sprayed on the surface of the mold either with or with-



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out masks and then set or fused. The vinyl sponge or foam is then cast into the mold and fused. The skin plastisol may also be slushed into the mold and cured, and then the vinyl sponge or foam cast and fused.

The above outline of methods is necessarily generalized; each molder has his individual ideas as to fusing time, fusing temperatures, methods of removing or eliminating bubbles, preheating of molds, etc. The suitability of the plastisol to the method and type of mold used can be determined only by experience.

References

For further information on vinyl materials, see p. 171. Also consult the Subject Index and the Directory Index, p. 1078.

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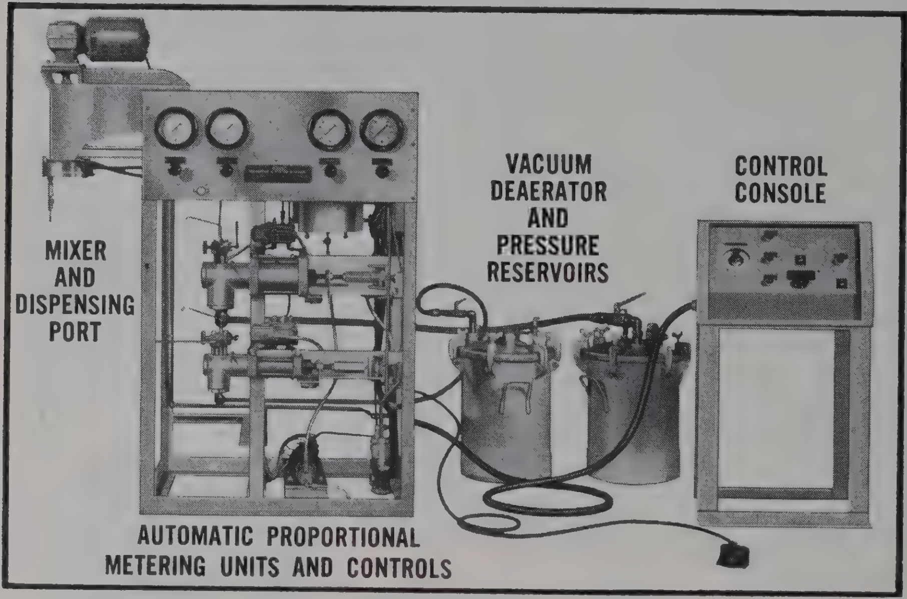
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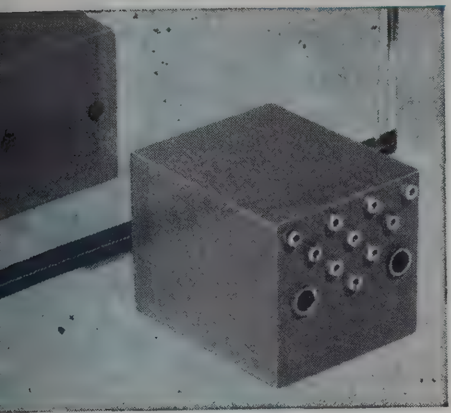

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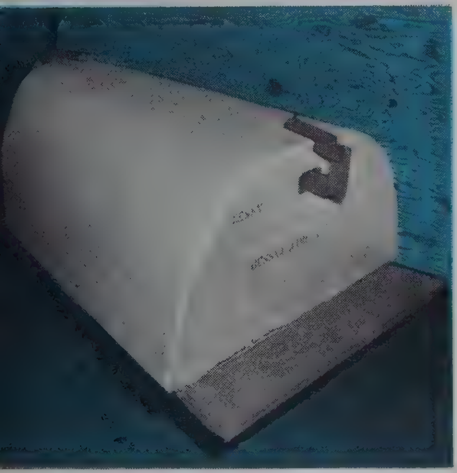

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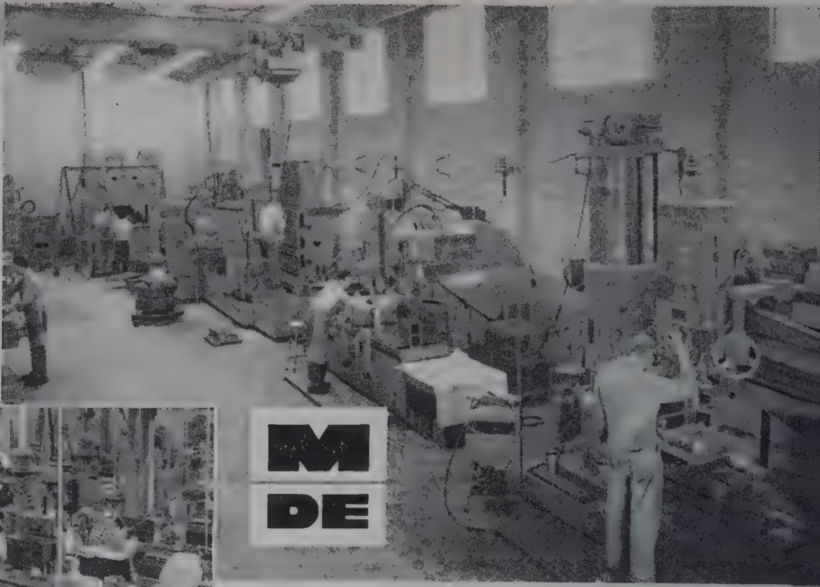

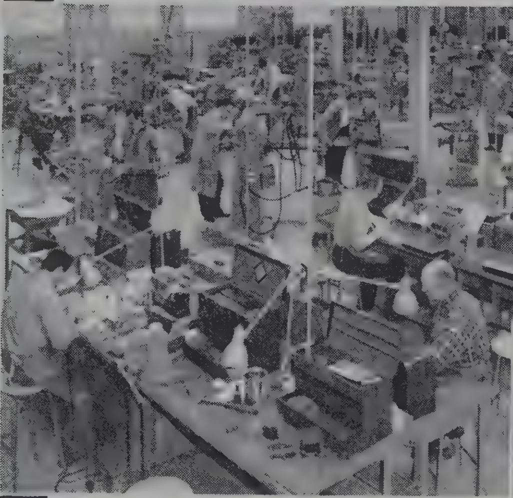

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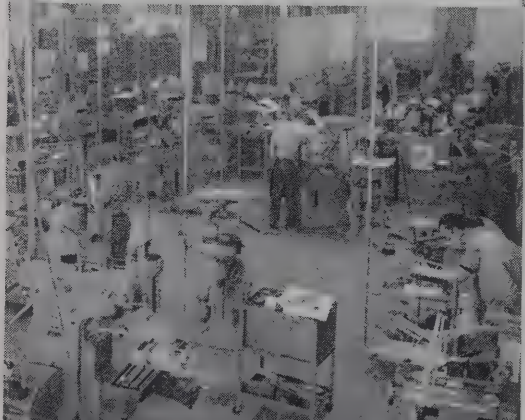

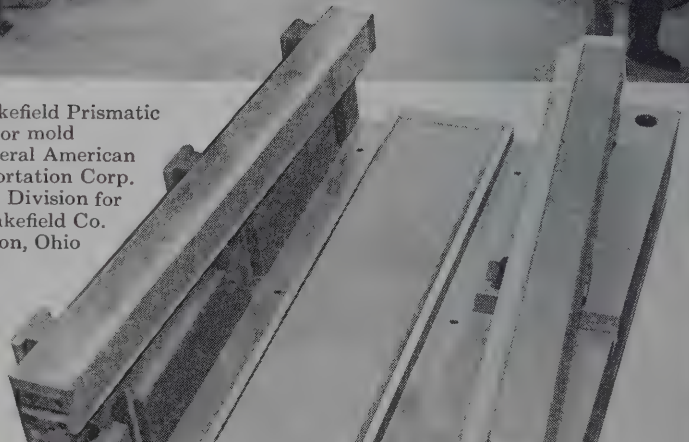

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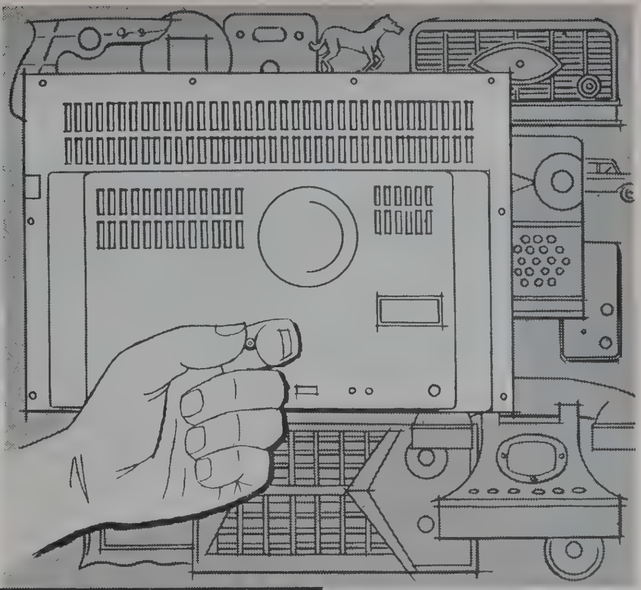

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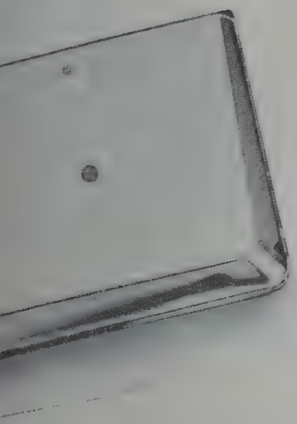

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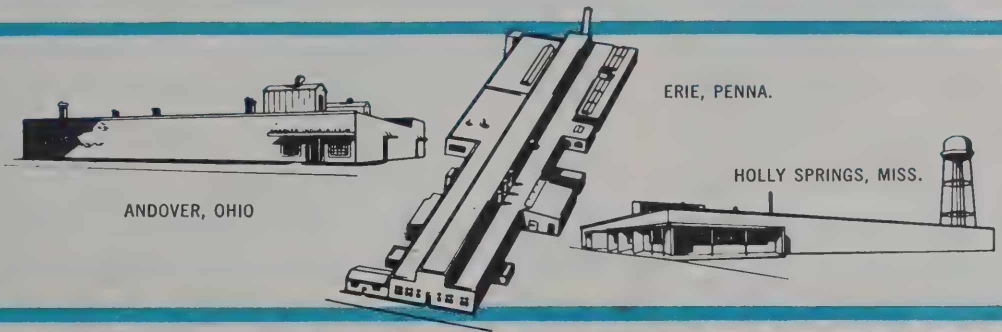
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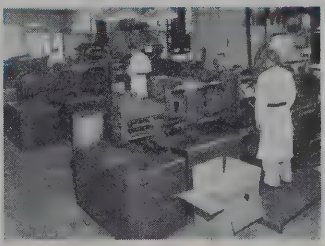

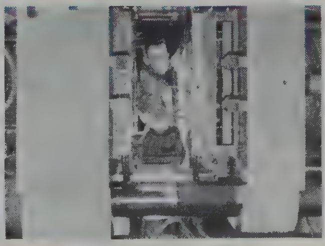

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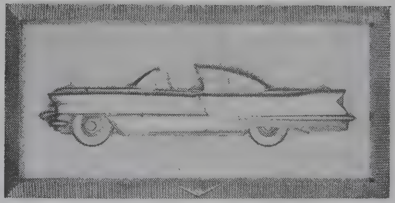
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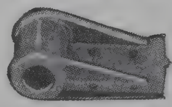
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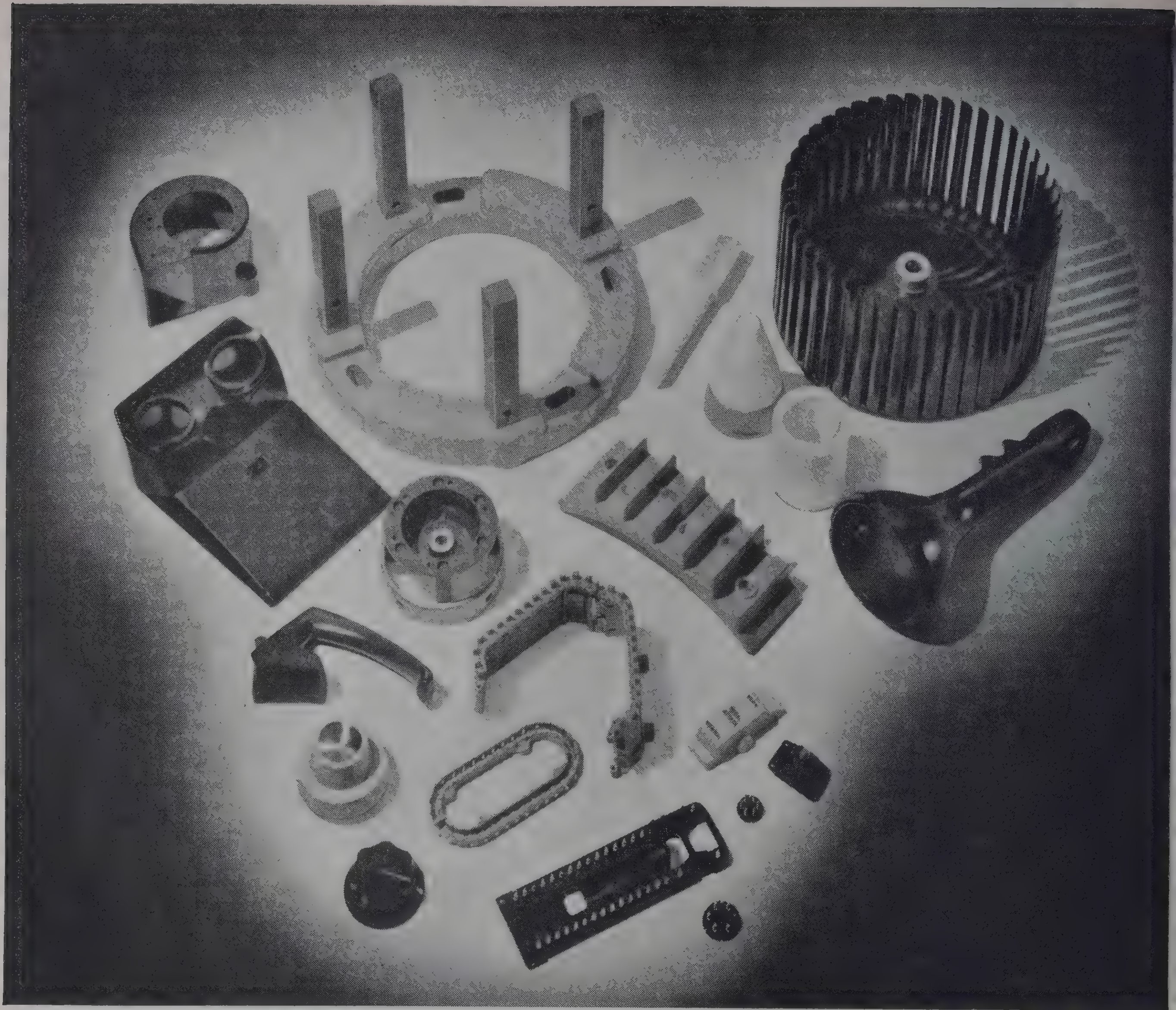

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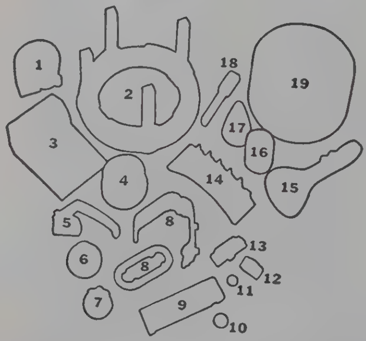

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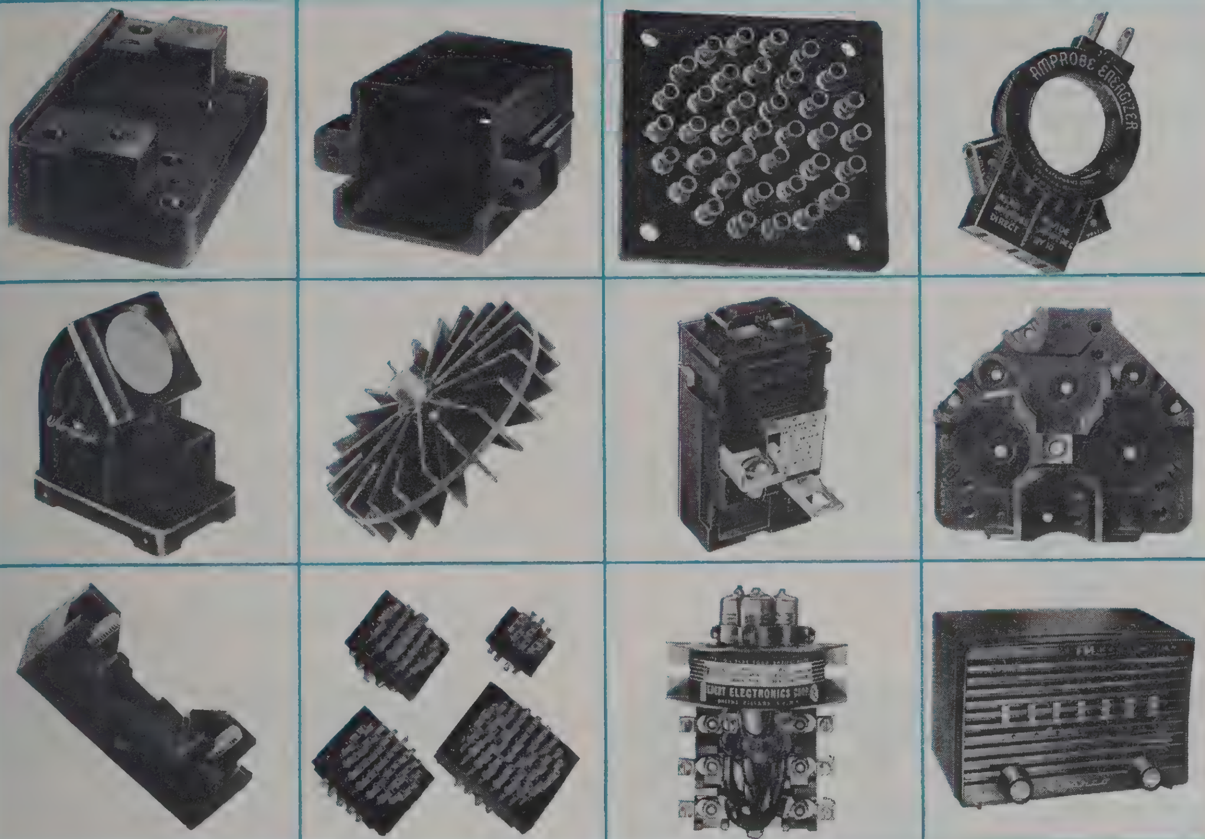

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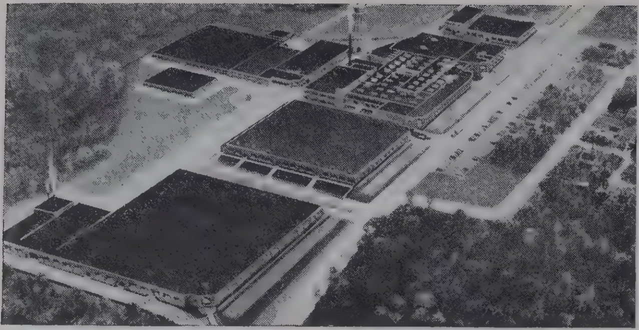

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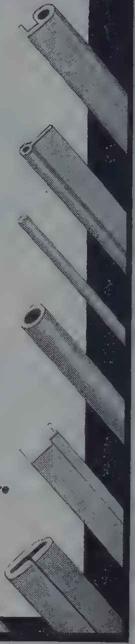
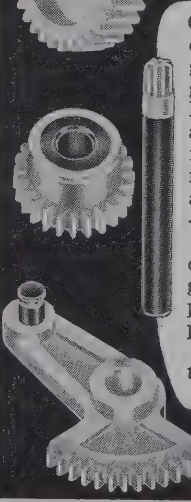
including NALGON tubing





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Our many years of successful production of Nylon Gears can now make even greater economies for you. With the great variety in molds now possible, Nylon should not only be considered as an economy measure but the answer to many problems where compact design is necessary. Nylon Gears are quiet, durable, efficient and need less lubrication — they mate perfectly with metal gears.

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Gears made only to your specifications. None carried in stock.

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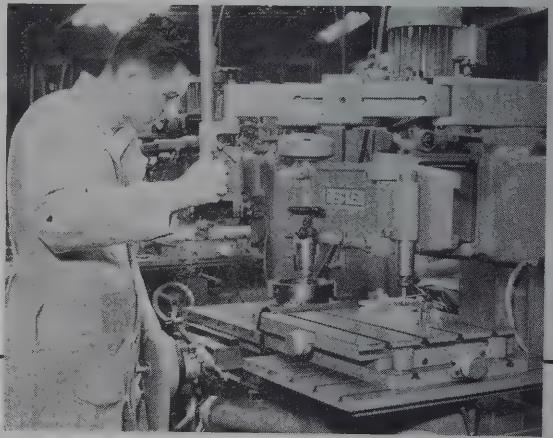

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for the Mold and Die Casting Industry

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ZYTEL*, DELRIN†, MARLEX**, and other Thermoplastics

. . . we "precision-mold" them all. And the fact that we have been serving many of the country's "top" manufacturers for the past 25 years and longer proves our ability to produce better moldings for *you*. Our equipment includes 19 of the latest molding machines, and plant operates on a 24 hour schedule.

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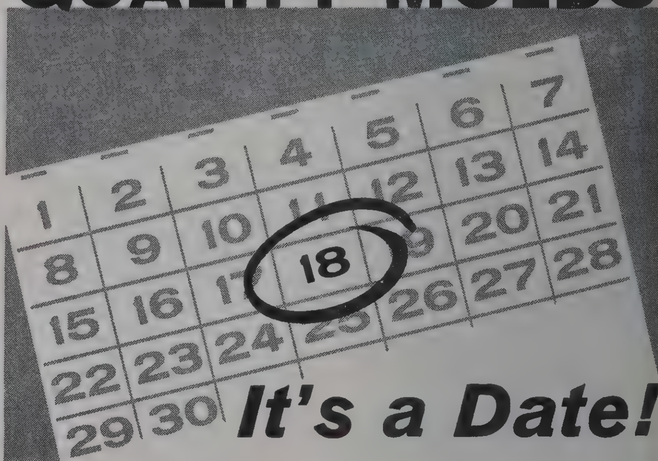

It's a Date!

And you can count on it

If it's delivered late, then even the best mold fails to satisfy. That's why Plas-Tool avoids anything except the most realistic estimates of when we will deliver your mold . . . and then we deliver exactly as promised.

For mold delivery you can count on, coupled with first-class engineering and quality workmanship, send your prints to . . .

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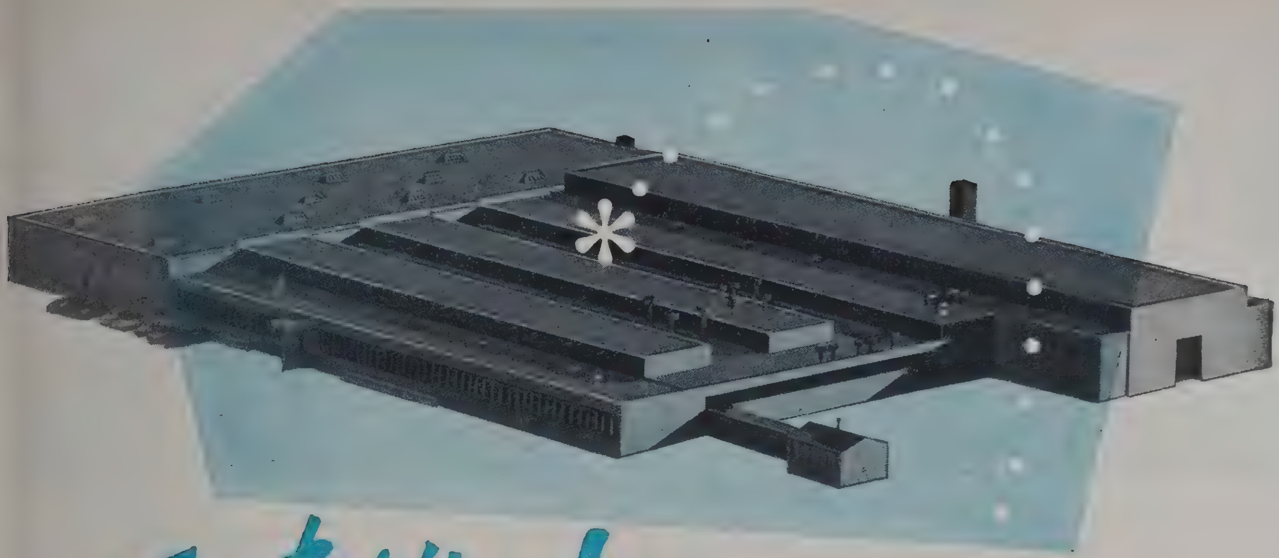
INJECTION • COMPRESSION • TRANSFER



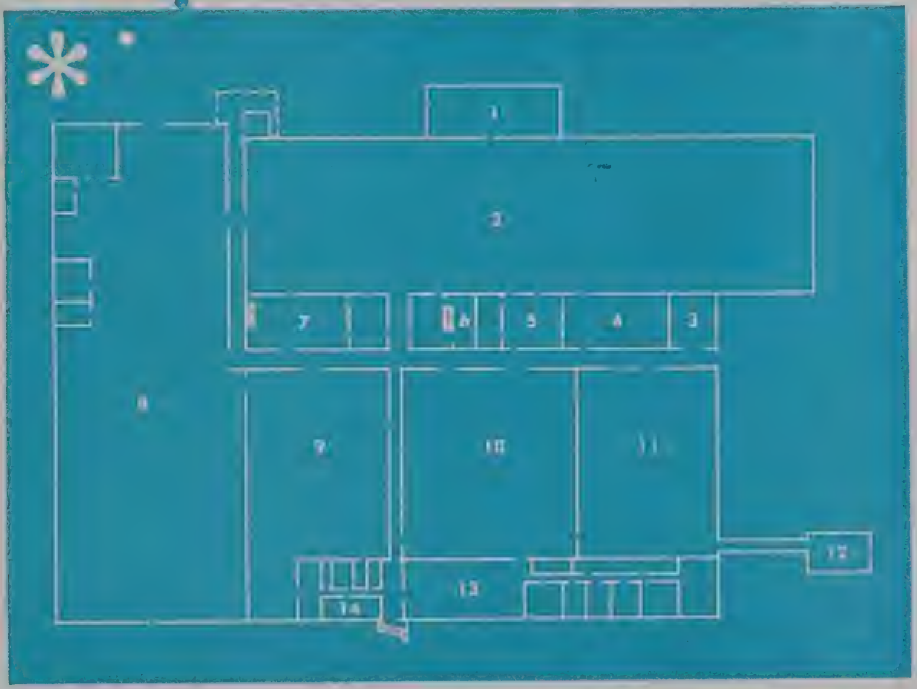
Factory Facts! about "Your plastics department"*

It is a new and complete injection molding plant, from modern tool room to all coordinated departments for supplementary operations such as assembly, decorative painting and printing and special packaging.

The quality and economy born of efficiency in a modern, custom operation are yours in our "start to finish service."

PLANT LAYOUT

1. Boiler and pump room
2. Molding room—32 presses 4 to 80 oz.
3. Air compressors
4. Lunch room
5. Shop maintenance
6. Employees locker rooms
7. Quality control
8. Warehouse and shipping dept.
9. Tool and die shop
10. Finishing and packaging
11. Decorative painting and imprinting
12. Paint and chemical storage
13. General offices
14. Drafting and engineering dept.



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Injection molders of thermoplastics

45 E. MARYLAND AVENUE
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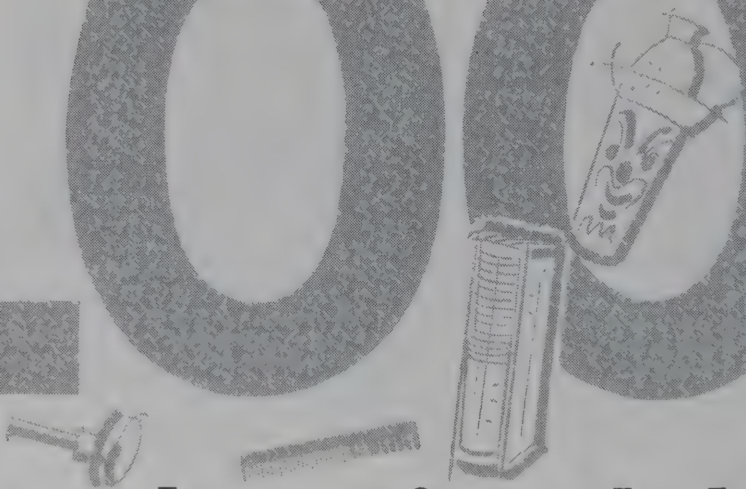

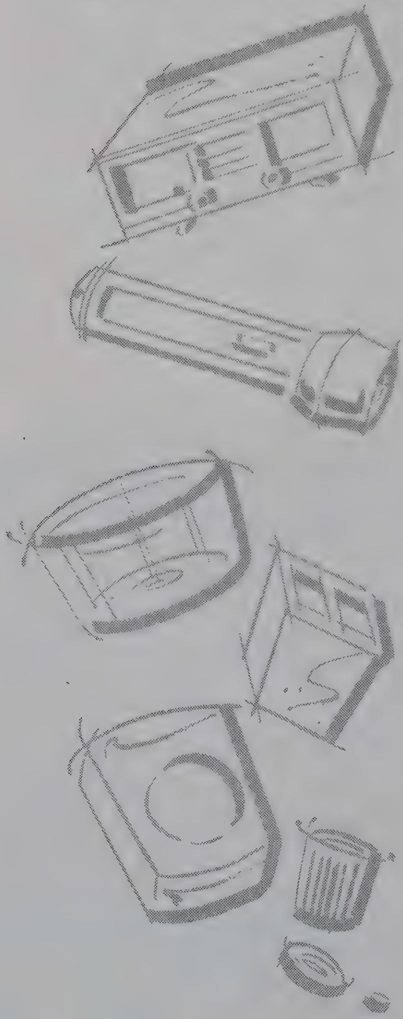

If variety is the spice of life, we're really living! The variety of molded plastic items which rolls out of our plant each week defies the imagination. Those who think of us strictly as specialists in molded plastic appliance parts just don't see the whole picture.

Sure, we're a major supplier to most of America's leading appliance manufacturers. If you need a radio cabinet, a freezer compartment door or a crisper shelf, we can make it for you — and do a good job, at a right price and on schedule.

But appliance parts are far from the whole story. Along with the appliance parts you'll find toys, housewares and items for many different products. As a matter of fact, if it's an injection molded thermoplastic item, you name it and we'll make it.

And production molding is just a part of Lincoln's service. Our engineers can often give you tips which will enable you to design your product for better performance or greater production economy. And when it comes to mold design, Lincoln engineers take a back seat to no one. Finishing and decorating problems? They cease to be problems when you tell Lincoln what you need.

So don't get in a buying rut. No matter what the item, be sure to get a bid from Lincoln. You may be surprised by how often we can do the job better, at a better price or on a better delivery schedule.

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apc

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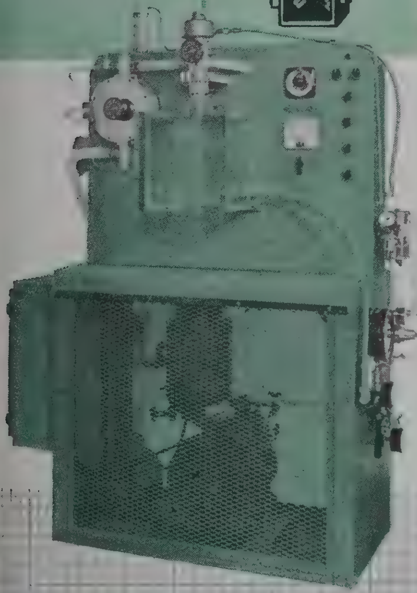

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Write or phone today for detailed information describing the HYDROSPENSER model specifically designed to meter, mix, and dispense multi-component resins for **your** application.

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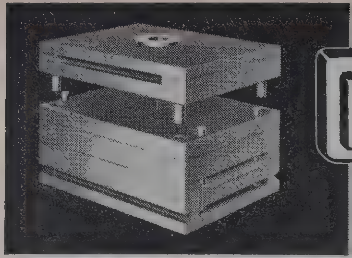
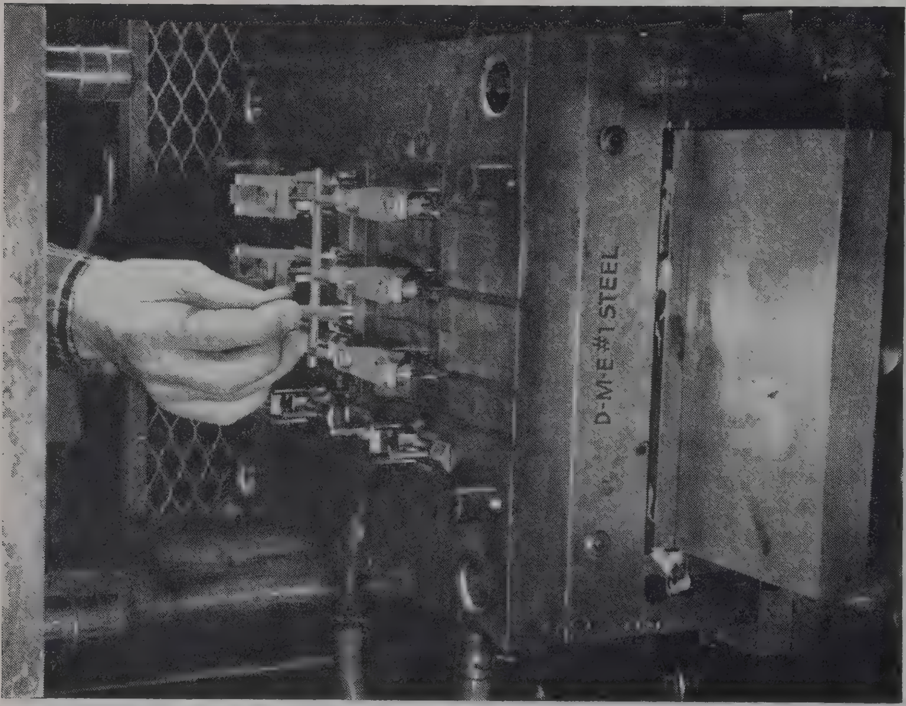


DME Mold Standards

DEDICATED TO QUALITY, SERVICE AND ECONOMY IN MOLDING



YOU SAVE MORE ON MOLD COSTS WITH OVER 6,000 D-M-E STANDARD MOLD BASES TO CHOOSE FROM

Largest Selection Saves You Time and Money

Whether it's a one-cavity "test" mold or a 60-cavity high production run, chances are D-M-E has the right size Standard Mold Base to fit the job and the molding machine.

D-M-E's 32 standard sizes, up to 23¾" x 35½", with 100 standard cavity plate combinations for each size, give you the largest selection of carbon or alloy steel standards available from any single source.

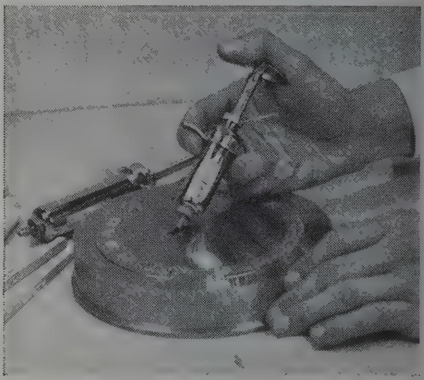
Save on Design Time, Moldmaking Time, Replacement Parts and Delivery

Design time is reduced by using D-M-E's full-scale Master Layouts and Catalog of specifications and prices. Moldmaking time is reduced because all D-M-E plates are precision ground flat-and-square, ready for cavity layout and machining. Exclusive interchangeability gives you the added saving of immediate replacement of any component part. And D-M-E's seven branch offices and warehouses are always fully stocked with Standard Mold Bases and components to meet your delivery requirements.

Cut Costs on Your Next Program

Start saving on your next moldmaking program, no matter how large or small. Take advantage of D-M-E Quality, Service and Economy.

THERE'S NO SECRET To a Fine Finish...



...With D-M-E's Line of Mold Polishing Supplies

Polishing mold cavities to a high lustre that is imparted to the molded piece was once "a well-guarded secret." But with D-M-E's complete line of mold polishing supplies moldmakers are able to attain the particular finish required by the part.

With D-M-E Diamond Compound, mirror finishes are produced in less time and at less cost.

Other time and money saving items for your polishing department include: D-M-E's Felt Polishing Kit, Abrasive Stones, Mold Polishing Compound, Abrasive Mounted Points and D-M-E-'s Mold Cleaner and Rust Preventive.

START SAVING NOW... Contact your nearest D-M-E Branch for full details and prices.

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- D-M-E of CANADA, Inc., TORONTO, ONT.: 156 Norseman Ave.

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. . . an infinite variety of standard plastic parts
plus complete custom molding facilities

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FREE
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samples
on request

PLATING ENGINEERING CO.

now offers

A Midwestern Source

for

**Electroformed Metal Molds for
Plastisols or Vacuum Forming**

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Low cost. Extremely accurate detail. High heat transfer—means rapid cure. Process good for multiple molds. You furnish wax or plastic pattern.

SEND print for free estimate
Sample mold (medium size) from your pattern $25.00
Electroforming in copper and nickel

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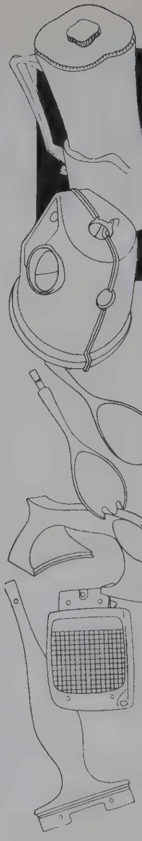

MOLDS
for the Plastic Industry

**COMPRESSION
INJECTION
TRANSFER**

The skill of experience has made Liberty tops in mold making. Using the latest in modern equipment, Liberty can make all types of plastic molds (including hobs and hobbings) to your complete satisfaction.
You are assured of precision work at a reasonable price.

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We are now serving leading plastics companies throughout the United States and foreign countries.

Southeastern Florida offers the best location in the United States for naturally accelerated actual weathering and sunlight exposure tests. Quick predetermination of permanency and durability is possible at all times of the year. *Write us today for full information.*

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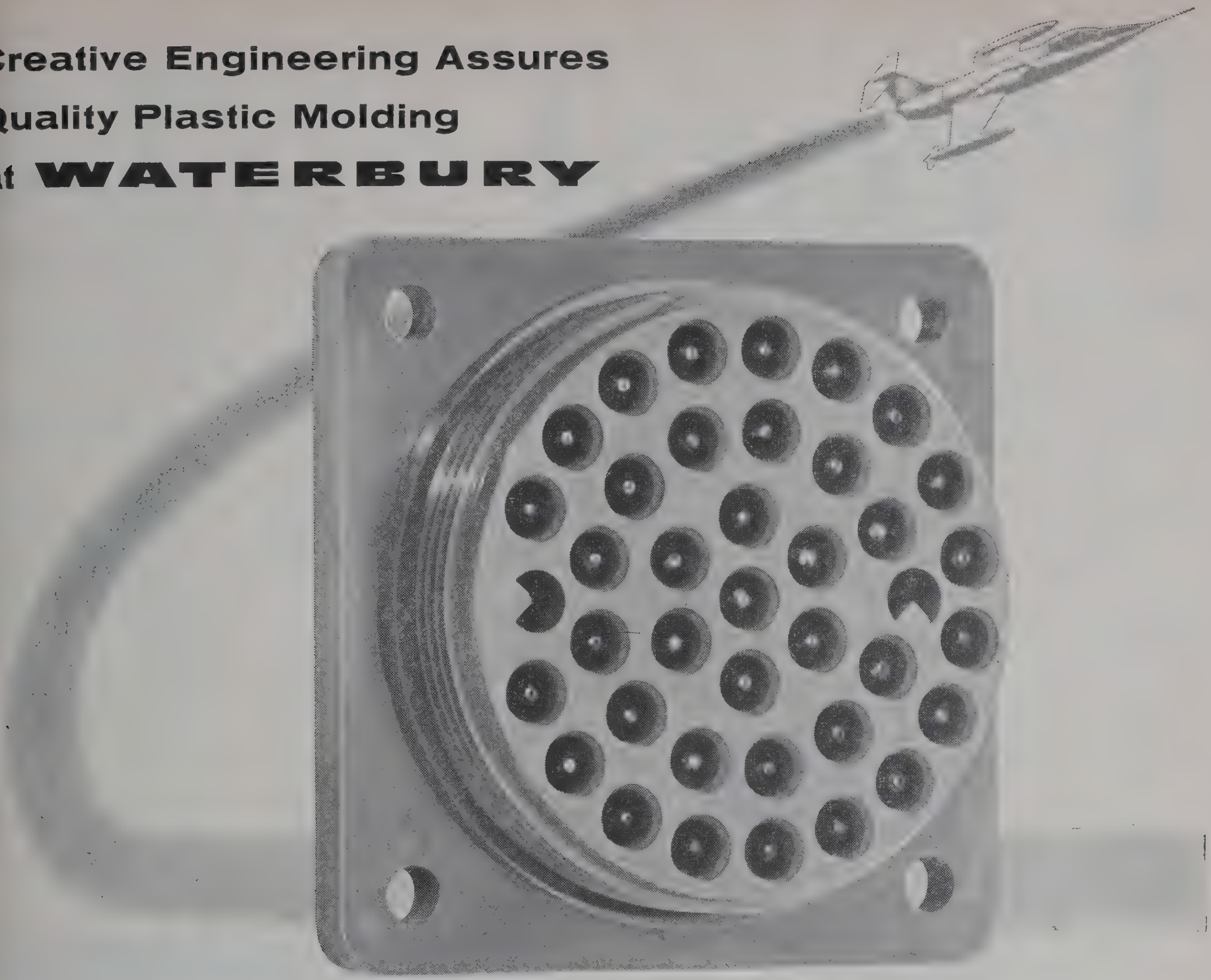
TESTING — INSPECTION — RESEARCH — ENGINEERS

Est. 1931

Creative Engineering Assures Quality Plastic Molding at WATERBURY



Flash-Free Metal Inserts

the problem There are thirty-seven silver-plated copper alloy inserts in this Diall-51-01 electrical plug connector molded for Burndy Corporation, of Norwalk, Conn. Each one must be free of flash if it is to perform its purpose.

the solution Molds were specially designed and built so that the 37 inserts could be blocked off to prevent flash on the inside of the bearing surface. In molding, constant pressure is kept on the shoulders by means of spring-mounted pins which compensate for pressure.

At Waterbury engineering and designing are integral parts of our operation. Problems are met and solved in the early stages of planning to assure quality and dependability in the molded plastic piece — compression, transfer or injection.

WATERBURY *Companies, Inc.*
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PLAZA 6·5551

Proof

When you have a product you'd like to have molded, you naturally want some advance indication as to quality, delivery and price. And the sounder the "proof" the better. That's why we think you'll be interested in these facts.

IT'S A FACT: Ideal Plastics places at your disposal one of the largest all-around facilities for mold design, production, finishing, assembly and shipping in America.

More than 80 injection molding machines whose capacities range from 3 to 60 ounces.

Two multi-million dollar toolrooms fully equipped to machine any mold that will fit an injection press.

A 25-man engineering staff with thousands of successful jobs behind them.

A 3,000-man labor force—composed of skilled molders, mold makers, experienced assemblers, finishers, inspectors, and packers.

IT'S ALSO A FACT: Your best guarantee of satisfaction is Ideal's sterling reputation among its current customers for "right" product materials selection, high standards of inspection, on-time delivery, and realistic, competitive pricing.

For a prompt estimate, simply write A. C. Manovill, Vice President in Charge of Sales, IDEAL PLASTICS CORP., 184-10 Jamaica Avenue, Hollis 23, N. Y. Phone: AXtel 7-7000.

Ideal *Better Molded Plastics for Industry & Home*

PIONEER of PLASTIC MOLDING

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THERMOSETTINGS

compression—transfer—automatic compression

THERMOPLASTICS

to capacity of our 8 oz. injection machines

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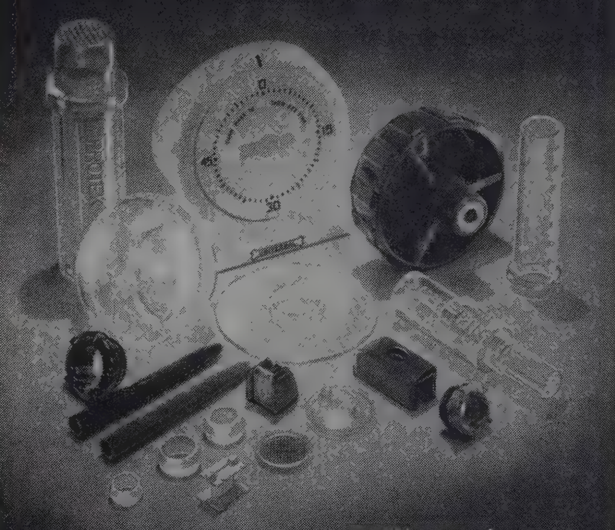

We can do it.

And in our shop that means we'll do it quickly, accurately, and at reasonable cost.

Just try us.

CONNECTICUT PLASTIC PRODUCTS CO., INC.
70 West Liberty St., Waterbury, Conn.

Facilities for every molding operation

backed by more than 80 years of integrity

In the field of custom molding industrial parts, Auburn Plastics, Inc—known for 80 years as Auburn Button Works—has a well-earned reputation for high quality, integrity and service. Quality control and on-time deliveries are routine.

In Auburn's completely integrated plant, competent mold engineering is matched by ingenious industrial engineering, squeezing the cost out of secondary operations, painting, decorating and assembling.

Flexibility in scheduling is assured by 25 injection molding machines with capacities up to 32 oz. Another 12 machines are available, if needed, at a subsidiary plant in Lockport, N. Y. —Norton Laboratories, Inc. (see separate advertisement).

Auburn's facilities include a complete 35-man toolroom with hobbing and Elox equipment; a large extrusion division (see separate advertisement, Section 4); and a battery of rotary and Stokes automatic compression molding machines for high volume production of small phenolic or urea parts. Such parts include knobs for top of stove ware and other parts having internal or external molded-in threads, automatically produced. Custom molded closures.

One of the few molders to do development work, Auburn now offers two new services:

RIGID VINYL, custom molded. This chemically resistant, hard to mold material, has amazing impact strength—up to 25 times that of nylon. Relatively inexpensive, rigid vinyl will not support combustion, has dimensional stability and is available in an unlimited color range.

EXTRUSION MOLDED NYLON. As licensee under a foreign patent, we can furnish nylon pieces of massive sections without "sinks." No limitation on weight or projected area. Relatively low-cost molds make this process particularly attractive to manufacturers whose anticipated volume is not large. We use this method to produce a 30" massive propeller. Write or call us and we'll be glad to give full details on this revolutionary technique.

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AUBURN, NEW YORK

ESTABLISHED 1876

Experience coupled with Imagination

at Norton Laboratories, Inc., Lockport, N. Y.

Since 1925, Norton Laboratories has been serving American industry as a competent custom-molder. Norton is now in a stronger position than ever to quote fair prices and deliver high quality molded plastic parts or assemblies.

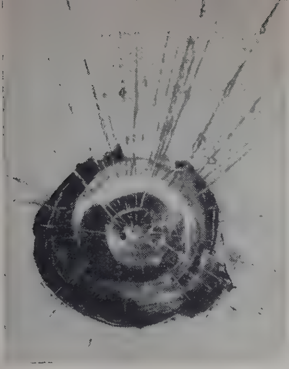
Norton's extensive equipment for molding thermosets includes 61 presses up to 500 tons capacity, of which 29 are of the plunger type. Thermoplastic injection molding equipment consists of 12 machines with capacities from 1 oz. to 16 oz. Automation is employed wherever practical. Employees now number more than 400. Service includes decorating and assembling.

Norton also has stock molds for the cosmetic trade — compacts and screw-top jars.

A "speciality of the house" is molding large or small rugged fibre-glass filled polyesters into housings and the like. Norton uses dry-blends in matched, hardened steel molds — does not employ the laborious lay-up method.

Send a print of your next plastic part to

NORTON LABORATORIES, INC.
Lockport, N. Y.
Est. 1925
A Subsidiary of Auburn Plastics, Inc.



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MACHINING THERMOPLASTICS

By H. Jack Kipnes*

Thermoplastic materials, by definition, may be readily molded into a limitless variety of forms and sizes, using any one of a number of molding procedures available today. However, where close tolerances are required, extremely small or large sizes are to be fabricated, and/or small numbers of parts are needed, it has been found that machining is often the most economical method of manufacture.

Typical of such products which could be produced only by machining is an electronic coil bobbin made of nylon. Molding would not have been feasible in this instance because of an extremely thin (7 mils) flange and a sharp corner between flange and hub. The behavior of nylon during the molding process is such that strong parts could not have been molded with these design requirements.

All thermoplastics can be machined either on standard hand or automatic screw machines or other equipment. Some can be machined using techniques comparable to those used for metals and wood, while some must be handled in a manner dictated by their individual characteristics.

In general, since thermoplastics become soft and pliable at relatively low temperatures, and have poor thermal conductivity and large coefficients of expansion, the problems of frictional heat build-up during machining become great.

Of all the thermoplastic materials available today, the most difficult to machine to any appreciable tolerance is the fluorocarbon TFE resin (e.g., Teflon[1]). Taking this as the most difficult material to handle and outlining the procedure in its machining, optimum conditions can be obtained for machining any thermoplastic. Where the machining precautions necessary with TFE are not required with other thermoplastics, or where modifications are necessary, substitute procedures will be described.

Unless proper equipment and techniques are used, thermoplastics machining can result in some obvious causes for part rejection, with subsequent loss to the fabricator. Among these can be included tearing, gouging, cracking, discoloration, and distortion.

To avoid these and other pitfalls, the following rules should be observed: 1) Use machines and tools in good repair; 2) If possible, restrict their use to plastics only; 3) Exercise good machine and shop housekeeping; 4) Generally, use high speeds and low feed rates; 5) Use coolant, except where material may react with it or be affected by it; 6) Maintain sharp cutting edges and proper clearance for chip removal; 7) Provide adequate material support, particularly in screw machining; 8) Minimize rechucking or repositioning; 9) Exercise quality control at the machine and again at final inspection; and, 10) Test each new batch of material before running.

Selecting stock

The machined part can be no better than the starting material. Choice of stock is especially important in the case of fluorocarbons, with their higher initial cost and the special care which must be taken in their machining, Porosity and incomplete consolidation, not readily apparent initially, can cause a high percentage of rejects and in-use failures.

The bulk of fluorocarbon parts today are machined from rod stock, which is available in many diameters. Molded tubing can be used to reduce waste on hollow parts. In both rod and tube stocks, it is wise to obtain stock whose outside diameter has been centerless ground to provide accurate chucking and cut down "whip" in a screw-machine operation.

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*Chief Engineer, Tri-Point Plastics, Inc., 175-177 I.V. Willets Rd., Albertson, L.I., N. Y.

References were prepared by the editors.

[1] Trademark of E. I. du Pont de Nemours & Co., Inc.

Thermoplastics, such as acrylics and high-impact styrenes, available in cast stock, should be examined carefully for bubbles and impurities.

This rule applies also to molded and extruded trifluorochloroethylene (TFCE) resin (e.g., Kel-F[2]). TFE resin should be white 100% virgin resin. Grey and dark spots are not cause for rejection, but should be kept to a minimum.

Machining equipment

Basic high-speed metal-working machines—lathes, hand and automatic screw machines, drill presses, grinders, and related equipment—are readily adaptable to thermoplastic machining. Stocks, chucks, spindles, beds, and cams must be in good repair to reduce production of out-of-tolerance parts. Machines and tools must be kept free of metal or other foreign particles which could imbed in or react with any of the thermoplastics to be handled. Housekeeping must be stringent in the case of fluorocarbons since contamination reduces their utility severely and dulls or chips the keen edge that is required of the tool.

High-speed cutting tools, preferably carbide-tipped, with meticulously sharp cutting edges, give the best results.

Maintenance of sharp cutting edges is extremely important in tools used in machining any thermoplastic. Tools should not be stoned by hand. Dull edges drag on the material and generate frictional heat which sets up conditions similar to those at which the thermoplastic was molded. Immediate results are expansion, softening, and even melting of the plastic. Nylon will actually melt on cutting edges of drills, and then burn, if proper techniques are not followed. Acrylics and polystyrene will soften and gum, causing the tool to stick, then tear the plastic surface. Most thermoplastics have poor thermal conductivity characteristics and will retain heat and confine it in the cutting tool itself. This causes rapid deterioration of the tool through softening and dulling. This phenomenon has given several thermoplastics, notably TFE resin, a reputation of being "highly abrasive."

Forming tools ideally should have a 15 to 20° top rake to facilitate rapid removal of chips and a 10 to 15° front clearance to reduce compressive forces which could "push" and distort the part. All forming tools should be so ground on a surface grinder that they provide "breaking" of sharp plastic edges (remove "whiskers"). Likewise, forming tools should have large cutting angles to accomplish the same purpose (see Fig. 1, below).

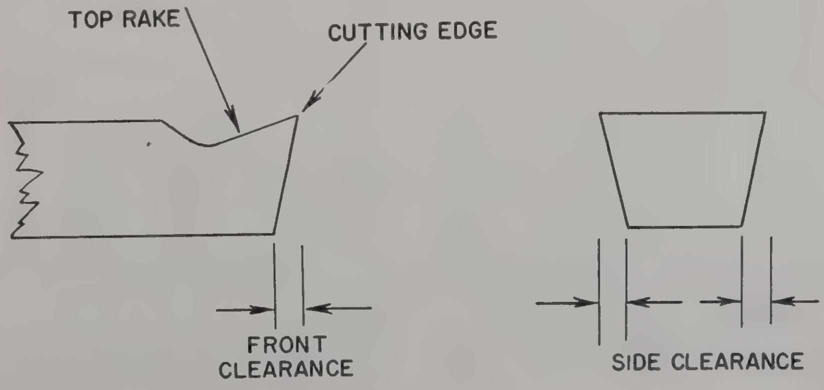
Drills, both twist and half-round, can produce clean, smooth holes only if their flutes are highly polished to speed up chip removal. Special "plastic drills" perform satisfactorily in most cases (see Fig. 2, p. 780). Half-round drills have the advantage of being readily reground and repolished in a plant's tool room when they show the slightest sign of dulling.

During drilling, particularly in the case of soft materials such as TFE resin, supporting bushings for drill and material are recommended for use with a half-round drill. These will keep the drill from "running out." Bushings should be accurately sized to provide firm material support while preventing squeezing or undue compression which could give rise to loss of tolerances. The importance of centerless-ground rod stock (for screw machining operations) figures heavily in this respect.

The softness of thermoplastics precludes the use of undue pressure during machining or forming. This is important in chucking or holding the plastic stock or semi-finished piece. Smooth surfaces which will not scratch or mark the piece are desirable. Spindles should run without build-up of heat which could then enter the plastic stock and cause undesirable expansion. Where the chucked stock is long enough to droop or wobble under rotation, live support must be provided.

Although compressed-air jets have been found effective in plastics machining to cool material and remove cuttings, it is far safer to standardize on "cutting" fluids, particularly in screw machining. Cutting fluids are used primarily for the rapid and effective removal of heat and also for removing chips from the cutting area. They are selected for high viscosity to facilitate removal of heat. Oils of about 100-120 S.A.E. are recommended for warmer months of the year; oils of about 60-80 S.A.E. for the cooler months. With fluorocarbons, it is usually necessary to increase the cutting-oil-reservoir capacity of the standard machine to permit the fluid to cool to room temperature before its return to the ma-

FIG. 1: Forming tools for working with plastics materials should be designed with 15 to 20° top rake and large cutting angles



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[2] Trademark of Minnesota Mining and Manufacturing Co.

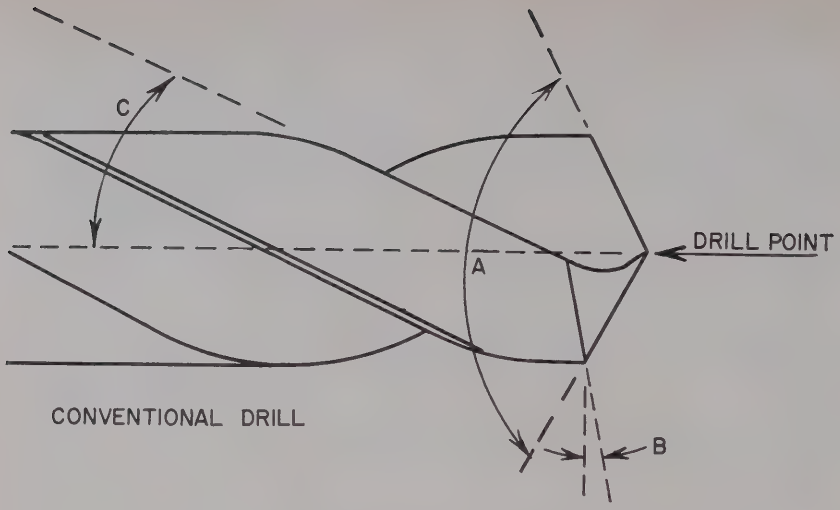

FIG. 2: Plastics drill configurations. A—point angle; B—lip relief angle; C—helix angle. Lip relief angle should be increased when being used for TFE resin and polyethylene and decreased when used for nylon. Point angle should be increased when being used for nylon

chining zone. It is inadvisable to cool cutting oils through refrigeration because of the risk of coagulating additives, etc.

Machining techniques

Where primary operations are to be carried out on a hand or automatic screw machine, centerless ground rod should be used. This eliminates initial turning or "truing" and cuts waste. With TFE resin, if diameter variations exceed 5 to 10 mils, machining may become extremely wasteful, if not impossible.

Work should be done with continuous lengths, using lathes and screw machines having a free "feed through" in the chuck to cut whip or torsion to a minimum. Conventional feed tubes are not satisfactory and stainless steel types should be substituted. Ample room must be allowed in the feed for stock to rotate freely. Depending on material and protruding length, rod stock may require support during machining. TFE resin, a soft material, requires internal or external support, depending on the operation. This applies particularly in center drilling, counter-boring, rough and fine turning, and even final cut-off.

Drilling and turning on TFE resin are done using a forward tool travel of between 5 and 6 mils per revolution, with ⅛- to 3/16-in. drills. Drill travel will vary according to the thickness of stock; heavier sections require higher "in-out" speeds.

Forming tools require a tool travel of from ¼ to 1 mil per revolution. Controlling variables, particularly in machining a TFE part, would be: stock speed, diameter of hole, and length of drill. Frictional heat may expand stock and result in a tapered hole. (See Fig. 3, p. 781.) It is best to use two or more rapid, full-depth passes with a tool of the required final size. An alternative would be to first travel the full depth with an under-size tool, and finish up with one of the required size. Another alternative would be incremental drilling with a tool of the required size, making sure that "dwell" within the stock at any time is kept to a minimum to prevent heating. When several diameters must be turned in the same piece, it is usually best to use the "rough-then-finish" technique. It is wise to keep on hand a complete stock of all drill sizes.

Thin-wall fluorocarbon sections may tend to warp due to stress relaxation (depending on the tool used). Material expansion is caused by the pressure of the cutting edge and the rate of feed onto the material. Compensation involves the use of a tool several thousandths oversize, which allows the finished wall to shrink to the required dimension. The peculiar behavior of fluorocarbons, TFE resin in particular, precludes establishment of any rigid machining rules. Techniques vary according to size and shape of piece and type of rod stock.

An example of the peculiar stress relaxation behavior of some thermoplastics is shown in Fig. 4, p. 782, and indicates compensation which must be made during machining to arrive at the final dimensions. Material for this part is stress-relieved to some degree by heat treatment. In this piece, one face must be optically flat, the other a concavity of exact dimension. If machined in the standard manner, that is, flat face first, then dished face, the piece would end up distorted. The "normalizing" of TFE resin during such a machining process, due to differential stress relaxation in sections of various thicknesses, would make the flat side convex, and the concave face more concave than necessary. The machinist must know, by past experience, what to expect and then adjust his machining technique to material peculiarities.

Stresses are never built up in machining plastics, with the exception of acrylic and styrene. Unusual stress relaxation can be attributed to improperly molded stock. This can be eliminated or minimized through heat treatment or machining. Heat treatment of TFE resin before machining or between machining operations can be accomplished at temperatures of 350 to 500° F. for periods of up to 24 hours. Pieces should be protected against contamination. Stress cannot entirely be eliminated by the heat treating operation.

Specific recommendations

Here are some specific recommendations on machining where techniques do not approach or, in other instances, go beyond, the precautions required for machining of TFE resin.

Polyethylene: Same as for TFE.

Styrenes, acrylics: Machining of styrenes should be done with plenty of lubrication. Cutting oils are used primarily for heat removal, rather than for actual lubrication. A high-viscosity, general-purpose cutting oil of about S.A.E. 100, or special formulations with detergent additives have been used with equivalent results. Viscosity should be adjusted according to the ambient temperature to provide for effective flow and "wetting" of the cutting surface. Without adequate wetting of the cutting surface, styrenes tend to get soft, melt, and stick to the tool.

As with TFE and other thermoplastics, cutting tools should have razor-sharp cutting edges, with drills having highly-polished flutes to facilitate chip removal. Form tools should have a 10 to 15° top rake, with 5° front clearance. Cutting edges should be generated with a surface grinder, *not stoned by hand,* to provide a correct working edge.

Styrenes are machined at rates slower than those used for TFE resin. Screw-machine stock rotation rates of up to 6000 r.p.m. are recommended, depending on the "free" length of stock and its diameter. Drills and internal boring tools should have a travel rate of from 2 to 3 mils per stock revolution, for stock of ½ in. diameter and less. They can be adjusted to slower rates for stock of larger diameter. Forming tool travel rates vary from ½ to 1 mil per stock revolution, and again are governed by the depth of cut and surface being generated.

Styrene is one of the few thermoplastics in which serious stresses can easily be developed if proper precautions are not taken during machining. Too fast rates, heavy tool pressure, and dull tool edges can cause stress which results in cracking during machining or in service.

To check on stress build-up during machining, the finished parts can be quickly and easily examined with the polariscope. Heat treatment of the stressed parts at a temperature of from 175 to 250° F. for from 1 to 4 hr. will normalize (i.e., relieve stresses in) the affected pieces. It is wise, however, to re-examine the heat-treated parts for any changes in dimensions that may have taken place. This is particularly true with parts where tolerances of 1 mil and less are sought.

Trifluorochloroethylene: TFCE resins, although closely related to TFE resins in molecular structure, are quite different in mechanical properties. Machining characteristics of TFCE are similar to those of brass and closer to those of the styrenes. It is run at slower speeds than TFE, with working speeds on automatic screw machines of around 3000 r.p.m., depending on stock diameter. Thick stock requires slow speeds and thin stock faster speeds. This is necessary because of frictional heat and the material's poor thermal conductivity. TFCE tends to melt, where TFE softens; its melting point is high —about 392° F.—but much lower than that of TFE (650 to 750° F). High stock speeds and/or heavy tool pressures will cause TFCE to melt onto the tool with subsequent binding or fracture of the tool's cutting edge.

Generally, machining techniques used with styrene will provide adequate results with TFCE. In drilling, the operator should be content with short and fast penetration, repeating the process to insure production of the required size and tolerance of hole. Drills should not be allowed to "load up" with chips, which will result in excessive frictional heat and variations in tolerances due to material expansion.

Nylon: The polyamides are relatively simple to machine. High-speed tool-steel drills and forming tools are adequate if cutting oils used are the general-purpose types recommended for other thermoplastics. However, since the polyamides are normally somewhat absorbent, use of oils and exposure of the resin to moisture should be closely controlled to reduce off-tolerances caused by excessive swelling by absorbed oils or moisture. "Soaking" may be necessary to approximate final use conditions. Exposure to formulated oils containing chemical additives can cause irreversible chemical changes in the resin with subsequent loss of tolerances and resin properties.

Maintenance of tolerances depends on cross-section of the stock. Heavy sections, due to the nature of the material, usually will not permit tolerances of less than 5 mils. Thin walls and cross-sections allow relatively close tolerances to be obtained.

Feed rates depend on the thickness of stock, but parallel those used with the styrenes. On the automatic screw machine, both turning and forming feed rates should be the same as for TFE, or around 6000 r.p.m. Rough drilling and finish drilling feed rates can be the same as for nonferrous metals. There are no problems with abnormal expansion or contraction of stock as found with the fluorocarbons, but intelligent use of techniques as to pressures and depth of cuts should be exercised at all times.

Turning rates and travel are

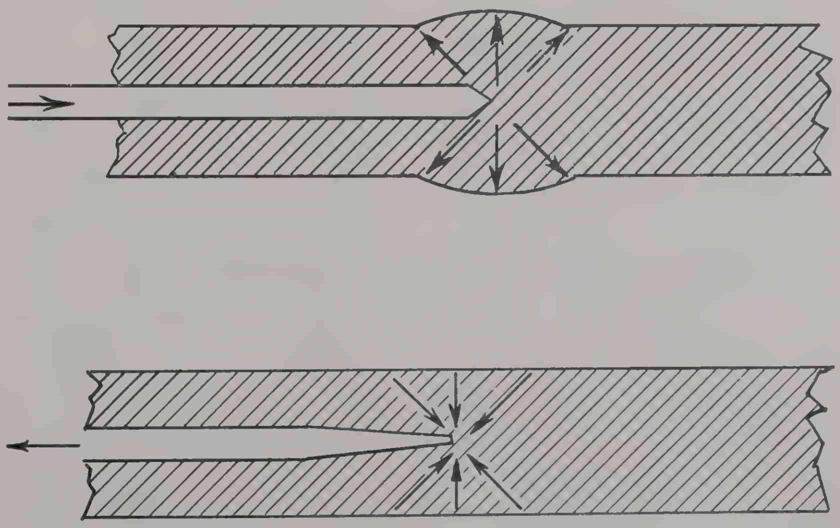

FIG. 3: Drill, upon entering plastic (top), heats it and causes expansion. When the drill is removed, the plastic cools and then contracts. Holes therefore become undersized and sometimes tapered

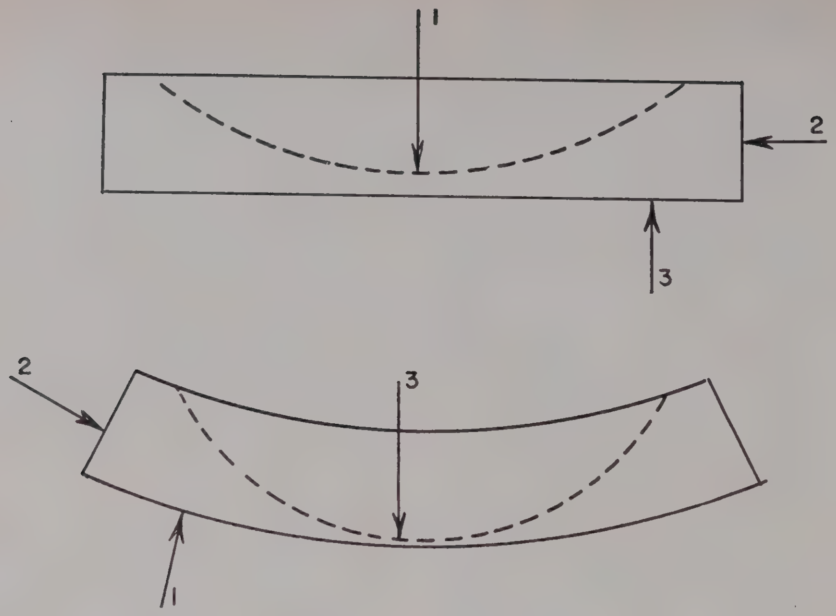

FIG. 4: Conventional machining techniques (bottom) when used with TFE resin must be modified (top) to compensate for stress relaxation. Numbers indicate sequence of surface machining. (See text, p. 780)

the same as for styrene. It is important to prevent formation of hairs or burrs, especially in milling and tapping, by "breaking" material edges with proper tool design or use.

In preparing tools for use with nylon, edges should be machine-ground, not hand-stoned, to an accurate front rake of 10 to 15°, with a front clearance of approximately 5°.

Phenolics: Under the heading of phenolics are considered not only the unsupported phenol- and urea-formaldehyde resins, but also those materials which contain paper, linen, canvas, nylon cloth, and other organic and inorganic materials as supporting matrices for these resins.

Carbide tooling is mandatory in working with phenolic-type materials because of the relative abrasiveness of these materials. They are, in addition, run "dry," without the use of cutting oils. In some cases, a controlled amount of cutting oil is allowed in close-tolerance work. In such cases, the oil is removed immediately after the particular operation is ended. The primary objection to cutting oils is reaction with the basic resin or absorption by the fillers, with subsequent deterioration of the material.

Equipment must be kept free of dust from the operation at all times to reduce abrasion of precise equipment parts. Phenolics are run at relatively slow speeds of 2000 r.p.m., with feed rates ranging from 2 to 3 mils per revolution in drilling and turning operations. Forming is not recommended on phenolics. All diameters are turned and, depending on the amount of "take-off" or "bite," feed rates may be the same as those which are employed for drilling.

Other forming operations, such as stamping and punching, are accomplished in much the same manner as with other plastics, with care taken in design of jigs to provide proper support and hold-down.

Melamines, silicones, and epoxies: Machining and forming operations are conducted in the same manner as for styrenes, with the exception of cutting oils, which cannot be used in most cases because of the risk of reaction with these resins.

When these resins are reinforced, their machining is similar to phenolics with a few modifications. Since these materials are generally considerably tougher than the phenolics, carbide tooling must again be used to cut the amount of frictional heat and tool dulling. These materials, like the phenolics, must be run dry, although some types of silicones and epoxies (chemically-resistant) can be machined with the assistance of cutting oils of the type recommended for styrenes.

Exhaust equipment is necessary and operators must take precautions especially on glass and epoxy.

Machining characteristics approximate those of nonferrous metals, with no significant volumetric changes taking place in the material during machining.

Because of the hardness and abrasiveness of these resins, it is necessary to keep machining equipment clean of chips and dust to reduce damage to beds, etc.

Secondary operations

On TFE resin, secondary operations such as drilling, counterboring, and milling must be carried out after the part machined has been stress-relieved as described.

Polystyrene and acrylics should be examined with the polariscope to determine the need for heat treatment before proceeding on secondary operations. Close-packed interference "fringes" indicate stresses which may give rise to off-tolerances or fractures during secondary operations.

Final inspection

Since cutting fluids or oils are recommended in most machining operations, final inspection is preceded by a thorough washing of parts in lukewarm water with detergent. After drying, tolerance and visual examinations are carried out to a degree required by the type of part produced.

For most thermoplastics, standard inspection techniques and instruments are used. Allowances are made for the relative softness or "give" that most plastics materials exhibit, as compared with metals.

In the case of fluorocarbons, TFE specifically, techniques and inspection instruments must be adapted to the peculiarities of the material. Micrometers and gages, ordinarily found adequate for other plastics and metals, are not adequate for critical tolerance TFE parts.

An example of this is the checking of ID's, where plug gages, not ID micrometers, must be used because of the softness and resilience of the plastic. Even with solid parts, the inspector must exercise a soft "feel"; otherwise an error of 10 mils or more can result. Thin-wall pieces sometime require special inserts for accurate outside gaging and outside support to permit ID gaging.

Quality control during machining is particularly important in obtaining required tolerances in TFE resin parts. In starting a new run, the screw machine operator knows that, depending on the part being produced, he will have to "mike" the first 10, 20, or 30 pieces coming off. In running off parts with tolerances of 1 mil, if the first 10 pieces show a variation from tolerance of from ¼ to ½ a mil, the operation may have to shut down and be "reworked" from the standpoint of tooling or machining sequence. In working with tolerances of this type, no more than 1 to 2% "off" tolerances can be allowed in the entire run. It is better to catch "off" tolerances at the machine than during the final inspection stages which follow.

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WELDING THERMOPLASTICS

By J. A. Neumann[*] and F. J. Bockhoff[†]

Weldable thermoplastics possess a fairly broad melting range, rather than a sharp melting point. Polyethylene and nonplasticized polyvinyl chloride are used to the greatest extent in welded structures; saran, methyl methacrylate, nylon, and polypropylene can also be welded if the technique is properly applied.

How to do it

In welding two pieces of thermoplastic, a set-up such as shown in Fig. 1, right, is used. The welding rod is of the same composition as the parts to be joined.

Compressed air is used for many plastics, particularly PVC. When welding polyethylene, however, an inert gas, such as nitrogen, is usually used to prevent possible surface oxidation and resultant faulty bonding. As the surfaces of the rod and sheet are softened, the filler rod is forced into the weld bed under slight pressure.

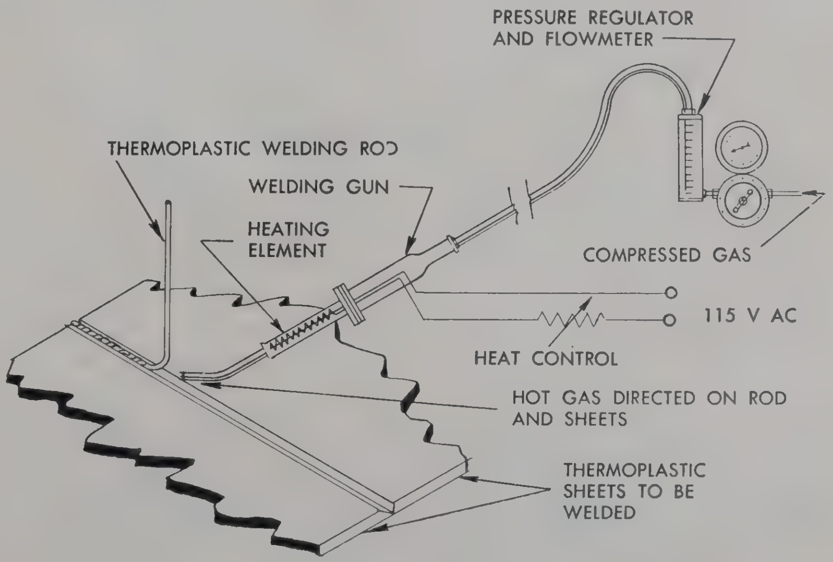
Diagrams of both electrically-heated and gas-heated welding guns are shown in Fig. 2, p. 784. Gun tips are straight and curved, to suit the operator's preference. Orifice temperature in welding varies from 400 to 600° F. and is controlled by regulation of the current in the electrical gun or of gas pressure and flow rate in the gas gun. The distance between the tip of the gun and the weld bed usually varies between ½ and 2 in. and within this distance a temperature drop of about 200° F. is experienced. Linear welding speeds of from 5 to 8 in./min. are commonly realized, dependent upon both the type of weld and the skill of the welder. It is important to maintain an oscillating motion on the tip of the gun in order to heat both the weld bed and the filler rod uniformly.

Weld Strength

Proper surface preparation prior to welding is necessary to obtain maximum weld strength. When making butt welds, the edges should be beveled to a 60° angle. When lap-welding or fillet-welding, the surfaces should be mechanically roughened. Solvent-cleaning is used in some cases, although it is not generally recommended for polyethylene, because of the danger of stress cracking. In the case of PVC, solvent-cleaning alone is usually satisfactory for the preparation of fillet-welds. Any lubricants or mold release agents used in the fabrication of basic components must be removed completely from the surface before welding.

Several types of welds are possible and some of these are illustrated in Fig. 3, p. 784. The correct angle between filler rod and weld bed varies with the type of material being welded. For low-density polyethylene, the rod is bent backwards in order to exert sufficient bonding pressure on the surfaces which are going to be fused. For more rigid materials such as linear polyethylene, non-

FIG. 1: Diagram (below) indicates the components and a typical arrangement used when welding plastics materials together. Heated gas from the welding gun is used to effect the assembly. Welding rod is of same composition as parts being joined. (Sketch, American Agile)


PRESSURE REGULATOR AND FLOWMETER
THERMOPLASTIC WELDING ROD
WELDING GUN
HEATING ELEMENT
COMPRESSED GAS
115 V AC
HEAT CONTROL
HOT GAS DIRECTED ON ROD AND SHEETS
THERMOPLASTIC SHEETS TO BE WELDED

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[*] President, American Agile Corp., P. O. Box 168, Bedford, Ohio.

[†] Asst. Professor, Chemical Engineering Fenn College, Cleveland, Ohio.

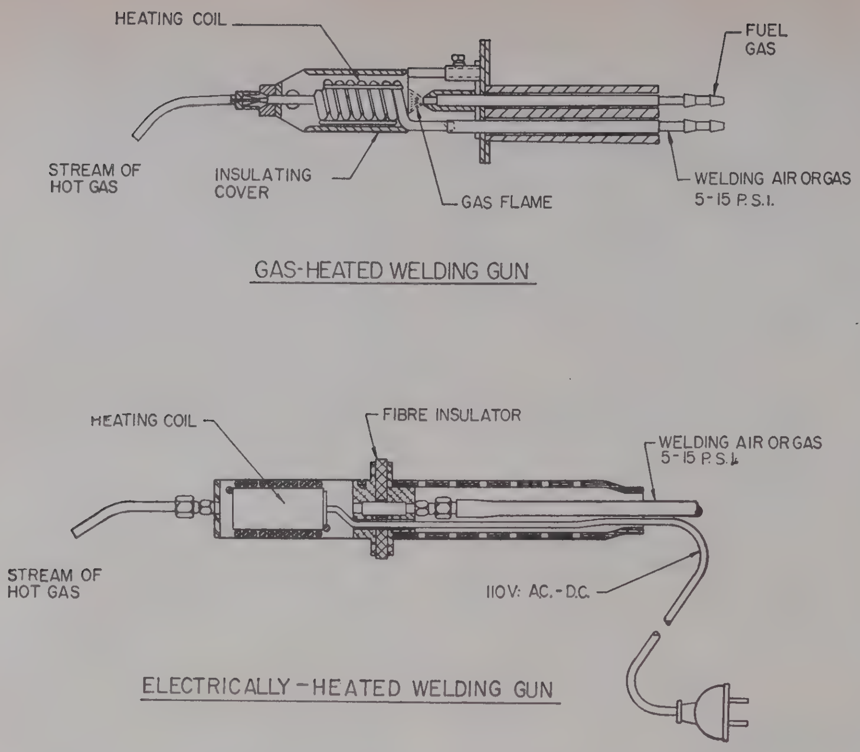


FIG. 2: Schematic drawings indicating types of gas-heated and electrically heated welding guns available. Orifice temperatures are controlled by varying gas pressure and flow rate (in gas-heated gun) or by a process of regulating the current (in electrically-heated guns)

plasticized PVC, or polypropylene, the rod is held approximately 90° to the weld in order to be most effective.

Testing methods

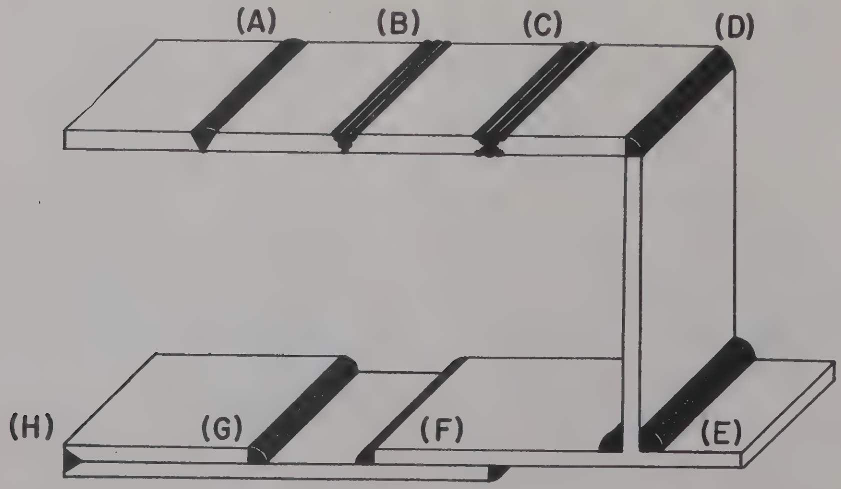
The strength of a weld is given in terms of weld value, which is defined as the ratio of the tensile breaking stress of a welded specimen to the ultimate tensile strength of the parent material, as follows:

$$W = \frac{S_w}{S_p} (100)$$

where: W = weld value (%); S_w = break stress on the weld (p.s.i.); S_p = tensile strength of parent material (p.s.i.).

Branched or low-density polyethylene shows weld strengths varying from 95 to 100 percent. Linear polyethylene exhibits lower weld values, in the neighborhood of 50 to 75 percent. It must be remembered, however, that the actual break stress of the weld is still higher than that of a branched polyethylene weld, because of the much higher ultimate tensile strength of the parent material. PVC welds exhibit weld values in the range of 75 to 90 percent.

FIG. 3: Six basic weld types: A) single-bead, single-V butt weld; B) multiple-bead, single-V weld; C) multiple-bead, double-V butt weld; D) corner weld; E) double fillet weld; F) lap weld; G) lap-bead; and H) edge weld. Each type requires special surface preparation, prior to welding, in order to realize maximum weld strength



In addition, the weld value of a crystalline material such as polyethylene, nylon, or polypropylene varies considerably with the molecular structure of the basic polymer. Weld value usually increases with increasing molecular weight and also increases with increased molecular chain branching or decreasing crystallinity in the case of low-density polyethylene. It is also a function of time and usually increases exponentially from the time at which the weld is completed. In the case of low density polyethylene welds, maximum strength is reached within 4 hr., although the piece can be handled within a few minutes after welding.

The quality of a weld has also been shown[1] to be dependent to a large extent upon the skill of the operator. Air inclusions, which give rise to weak welds, can usually be observed in natural polyethylene by the use of a strong inspection light held at an oblique angle to the weld.

When opaque or pigmented filler rod is used, minute cracks and pores in weld seams can best be detected by spark-testing. This is particularly useful for the examination of tank liner welds, since a steel supporting tank will serve as a good electrical ground.

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ADHESIVES FOR PLASTICS

By Bernard Gould*

As a result of the increasingly widespread use of all forms of plastics in industrial production, not only have many new adhesive formulations been developed during the past year, but scores of different uses have been found for older adhesives. The relationship of the plastics and adhesives industries has become more and more intimately intertwined because of the natural affinity between these two groups.

There are a number of reasons for this alliance, and low material cost is but one of the factors which have brought about this interrelated growth pattern. Both plastics and adhesives usually have a low initial cost and, since this is frequently one of the basic reasons for the decision to use plastics, the incorporation of "chemical fastening" techniques to join plastics to themselves as well as to other materials is a logical step. Modern industrial adhesives also call for fewer specialized workers, permit greater speed of assembly, and require less after-finishing than do conventional methods, all of which contribute to greater production economy.

In addition to these direct savings, there are other equally important but perhaps less obvious "plus" benefits to be derived through the use of adhesives. A number of these stem from the intrinsic characteristics of plastic materials themselves, others from the generic advantages of adhesive-bonding. Frequently, adhesive-bonding is the *only* means by which a satisfactory joining job can be done.

Certain plastics cannot be bonded to each other or to other surfaces by thermal welding or heat-sealing techniques because the temperatures involved are higher than those which the plastics can withstand. For such materials, special modified epoxy, 100%-reactive, solvent-free formulations, designed to bond at room temperature, have overcome this problem.

For materials which can withstand moderate heat and some pressure to effect a bond, other new adhesives have been developed in dry film form and even new solvent-dispersed, rigid-curing, structural adhesives have become available.

"All-plastics" assemblies, used where exposed metal must be avoided, also demand the adhesive joining process. In applications where chemical-resistant plastic sheetings such as Kel-F or Teflon are used as covering or lining material, an unbroken surface is essential if the basic objective is to be achieved. Only adhesives provide a means of bonding the components without rupturing the protective plastic surface.

Thinner plastics films and most plastics foams may not be rigid enough to withstand the increased stress concentration at points where conventional metal fasteners might ordinarily be used. This potential source of bond failure can be eliminated by the substitution of an adhesive which dissipates stresses over large areas.

An adhesive formulation which may easily be applied with a small brush, for example, makes possible the joining of hard-to-handle, small, or irregularly-shaped parts. Conversely, an adhesive designed for automatic spray machine application simplifies and speeds the bonding of large areas such as are encountered in the assembly of sandwich panels.

"Chemical fasteners" take many forms: liquid adhesives are available in a wide range of viscosities and percentages of solids (from 5% to 100%) and literally hundreds of formulations are produced in paste, powder, or dry film forms so that there is a choice from which to meet almost any individual production application requirement.

Numerous specialized features can be "custom-built" into adhesives to add to their versatility. For example, when materials with differing coefficients of expansion are joined, a "flexibilized" adhesive can compensate for movement when temperature changes occur. Specifically formulated primers and tie coats have been developed to restrict plasticizer migration, thereby making possible trouble-free bonding of vinyls and other plasticized thermoplastic materials.

The actual design of an assembly involving plastics can be varied considerably when adhesive-bonding is selected as the joining method. The designer finds that he now has a wider choice of basic component materials and a greater variety of production techniques with which to produce a sturdy assembly. Simplified design and lighter weight, as well as more efficient and economical handling, storage, and shipping of the completed unit, often result.

Beyond these advantages, adhesive formulations simultaneously perform functions other than bonding: heat or electrical insulating; sealing, which may be particularly important if liquids or gases are encountered in end-use; or vibration damping. They may also be used in conjunction with other joining methods for temporary holding of parts, to add supplementary strength to the joint, or for auxiliary holding in areas inaccessible to other joining materials.

More and more of the design concepts developed by today's product engineers appear to involve production and end-use service requirements which can be satisfied only—or far more efficiently—through the use of modern industrial adhesives.

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*Manager, Market Development, Rubber and Asbestos Corp., 225 Belleville Ave., Bloomfield, N. J.

References were prepared by the editors.

Specialized Adhesives

Significant developments in adhesive technology during the past year were, for the most part, directly related to the expanded markets which were created for specific plastics.

. . . for polyester film

One of the many uses of polyester film involves its lamination to resin-impregnated asbestos papers, kraft papers, rag papers, varnished papers and fabrics, and similar electrical insulation materials to produce phase and layer insulation in electrical motors, generators, and transformers.

For such applications, new resin adhesive formulations have been developed to yield superior resistance to organic solvents and hot oils. After many hours immersion in toluol, one such formulation retains nearly all of its initial strength while wet and recovers it completely after drying. Thus, electrical machinery which has been insulated with laminations produced with this adhesive can be dipped in varnishes containing aromatic solvents and still maintain full bond strength as well as maximum dielectric strength. In fact, adhesives of this kind actually add to the dielectric strength of the lamination and offer excellent resistance to heat-aging as well. For example, many manufacturers make laminations with such adhesives which pass Class B insulation heat-aging tests; i.e., 96 hr. at 125° C. (257° F.).

. . . for polyethylene

The building industry was quick to realize the advantages of wide width polyethylene sheeting as a material for moisture control in new construction. Early installations were made with asphaltic compounds which had definite limitations. Today, however, a fast-grab, high-tack, waterproof, synthetic rubber-resin adhesive is used to bond the sheeting to walls, floors, foundations, or ceilings—or to another polyethylene sheet where lap joints are required.

Bonds may be made up to two hours after the adhesive is applied, allowing enough time for the entire foundation to be coated before application of the film, so that the vapor barrier can be wrapped around in one continuous operation, if desired. As a result, one or two men can now easily and more quickly accomplish a job which formerly required a crew of ten.

. . . for vinyls

Perhaps the biggest stride in the use of vinyl plastics in the past year has been fostered by the markedly increased introduction of vinyl-clad metal into many phases of industrial production—housings for business machines, luggage, radio cabinets, and a wide variety of other equipment and appliances. These vinyl-clad metal laminates are comprised of either smooth or embossed vinyl sheeting bonded to steel, aluminum, or magnesium. These rugged laminations can be formed, reverse bent, folded, redrawn, stamped, sheared, and punched without damage.

New developments in the field of adhesives for this specific application have been in the direction of formulations which can be reactivated at lower temperatures than formerly possible. This factor is particularly important since high heat frequently results in smoothing out the decorative pattern in the vinyl under pressure, thus defeating the purpose of its use. New adhesives for this process are said to provide satisfactory bonds, even with improved heat-resistance, at well below the 350° F. temperature formerly considered minimum.

. . . for fluorinated polymers

The frictionless surface of such plastic sheetings as Teflon polytetrafluoroethylene and Kel-F polytrifluorochloroethylene makes them invaluable as coatings and linings for tanks, chutes, and other materials handling equipment, as well as for scores of other industrial uses. However, this "slippery" characteristic made adhesive-bonding impossible at first and it was not until these sheets were produced with one side treated for bonding that adhesives could be used. This, in turn, called for 100%-reactive epoxy-based formulations which require only enough pressure to assure intimate contact of the mating surfaces during cure.

The first epoxies developed for this work were relatively heavy pastes but, since these liners were equally useful when applied to cylindrical or irregular surfaces, the need for easily brushable adhesives soon became evident. The free-flowing variations of the heavier formulations which were then evolved provide the same excellent bonding characteristics with the added advantage that hard-to-reach or rough surfaces can be uniformly coated with adhesive.

. . . for epoxies

In printed-circuit work, a growing demand for flame-resistance in the baseboard, higher strength, and better electrical properties in the finished circuit resulted in the development of epoxy/paper laminates; the requirements could not be met by the available phenolic materials.

Concurrently, there arose wider exposure of the completed circuit to end-use service conditions where the need for gold or silver plating of the circuit became essential. Since such plating baths are alkaline in nature, an adhesive had to be developed which would be as resistant to these alkaline conditions as is the epoxy/paper base material.

The adhesives which are now being used to bond copper foil to epoxy/paper printed circuit bases provide a stronger bond, are alkaline resistant, and provide better electrical characteristics than were previously thought possible.

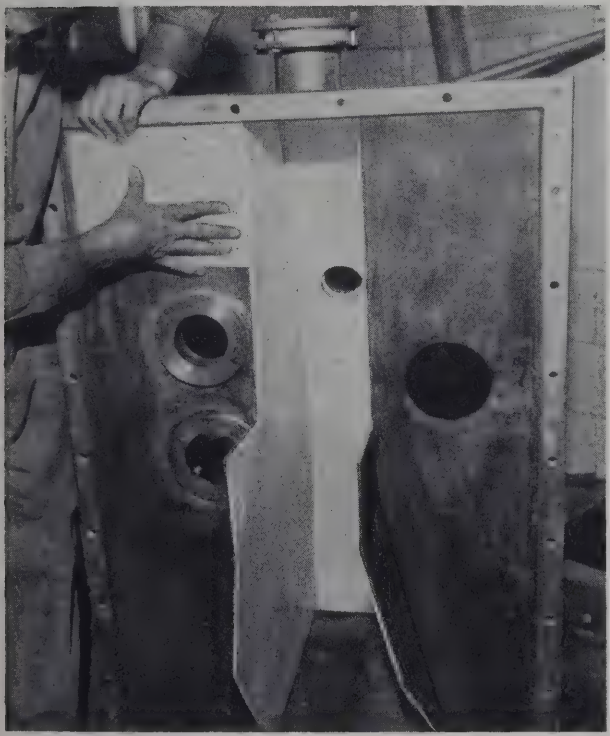
. . . for reinforced polyesters

Formerly more or less limited in volume production to decorative uses, the reinforced polyesters are now coming into their own in structural applications. Typical of this is the joining of such plastic sheets to aluminum frames to serve as skylights in truck trailer manufacture.

The bonding problem here emphasized a need for precise control of adhesive application and accurate positioning within a narrow area. Liquids or pastes could, of course, be used but the newly-developed synthetic rubber-resin

ELECTRICAL CHARACTERISTICS of adhesive for coating electrolytic-grade copper used in printed circuits are comparable with those of epoxy-paper base to which the copper is bonded

TRIPLE-DUTY epoxy adhesive is used in constructing "all-plastic" astrodomes of foamed polystyrene blocks and epoxy-reinforced fibrous-glass cloth. The adhesive bonds the foam blocks to each other; it bonds the foam to the glass; and it partially impregnates the glass cloth



CENTRIFUGE LINING of cementable Teflon tetrafluoroethylene resin is adhered to stainless-steel structure with a 100% reactive epoxy adhesive. (Photos, Rubber and Asbestos Corp.)

FLEXIBLE URETHANE FOAM, used in the manufacture of marine seat cushions, is bonded to itself and to wood, plastics sheeting, etc., with a special solvent-dispersed epoxy adhesive which features fast grab and soft seam

ENTIRE BUILDING FOUNDATION can be rapidly wrapped with polyethylene barrier by only two men, after the walls have been "spotted" with fast-grab, high-tack waterproof mastic adhesives in dry film form are particularly well suited for such a critical application.

First of all, adhesives in film form are extremely convenient to handle. They are not tacky and can be easily cut to the desired size and shape with conventional dies or even with scissors. The cut pieces may then be placed exactly where they are needed.

Further, there are alternate methods of reactivating the dry film to effect the bond. It can be lightly wiped with solvent before being placed between the mating surfaces and a strong bond achieved at room temperature. Or, if heated presses are available, the adhesive-filled "sandwich" can be heat-reactivated under pressure for even greater strength.

. . . for flexible foams

When flexible plastics foams, particularly the urethanes and vinyls, joined rubber latex foams as comfort cushioning materials, they involved the same *basic* application and service requirements as did rubber latex foams. Adhesives already available for latex foams provided: a) the necessary immediate tack loss; b) the fast "grab" needed for production efficiency and speed; c) a bond stronger than the foam itself; and d) a seam comparable in softness to the resiliency and texture of the foam.

However, when the new plastic foams came upon the scene, their special characteristics demanded compensating adjustments in the formulation of adhesives used.

The incorporation of new synthetic polymers was one of the important special features of the improved formulations. They provide greatly improved spreadability, making possible the easy application of glue lines of minimum thickness without the "bare spot" hazards encountered with earlier adhesives. These thinner glue lines produce even softer seams, yet resultant bonds are stronger than ever before. And because the glue line is thinner, there is the added economy of increased coverage per gallon.

Flexible plastic foams also offered a number of advantages which fitted them for service in many diversified fields of industrial usage when bonded to other materials: metal, wood, fabrics, rigid plastics, concrete, etc. These varied assemblies, in turn, presented a broad range of service requirements for the adhesive. When, for example, flexible foams are combined with fabrics in the clothing industry, the adhesive must withstand drycleaning and washing and, additionally, must not stain the materials which it bonds. When vinyl foams are used, the adhesive must also be able to overcome plasticizer migration.

Further, because production facilities and joining techniques frequently vary from plant to plant within a single industry, it became necessary to virtually "custom-tailor" basic formulations to meet individual needs. As a result, a wide range of viscosities to allow for different methods of adhesive application, faster-drying solvents, or formulations which provide specific adhesion to other plastics, are all among the specialized steps made in this direction.

. . . for rigid foams

The use of rigid foamed plastics, expanded polystyrene in particular, also created a considerable demand for advances in specialized adhesives technology.

The building industry was quick to realize the obvious advantages of these foams as insulating material and adhesive-bonding was already a widely used fastening method in this field. But the use of what appeared to be an ideal combination of materials and method was sharply limited when it was found that most conventional adhesives contained solvents which attacked the cells of the plastic foams.

The first step, then, was to bring out low-cost reclaim rubber mastics dispersed in special solvent blends to minimize the hazard of cell collapse. Water-dispersed adhesives of the same general type further reduced the possibility of cell damage and offered the added benefits of nonflammability and simplified clean-up procedures.

Like the flexible foams, the rigid plastic foams were quickly adopted by many other industries. These new uses involved mating to many other surfaces such as wood, metal, and other rigid plastics, especially as core material in sandwich panel assemblies of all kinds.

For example, in the production of sandwich panels comprised of rigid foamed polystyrene cores between metal or rigid plastic "skins", certain components, manufacturing facilities, or end-use service conditions may demand the use of 100%-reactive, room-temperature-curing modified epoxy formulations.

If one surface is a relatively soluble thermoplastic (such as polystyrene in rigid sheet form), an adhesive of this type is essential since it eliminates the need for detrimental heat and pressure during joining. In addition, adhesives in this group yield moisture- and chemical-resistant structural bonds which remain unaffected within a temperature range from below zero up to and even beyond the melting point of the foam itself. They represent the special approach called for by unusually severe environmental conditions which the completed unit may face in normal service.

The modified epoxies also readily lend themselves to doing double or even triple duty. A graphic example of one such application is the construction of astrodomes consisting of blocks of foamed polystyrene between skins of epoxy-reinforced fibrous glass cloth.

In this job, a semi-thixotropic, room-temperature-curing modified epoxy is brushed between and on top of the foam blocks and the glass cloth is laid up on the adhesive-coated surface. The adhesive performs three functions: it bonds the blocks of foam to each other, it bonds the glass cloth to the foam, and, serving as a "laminating" resin, it partially impregnates the glass cloth.

Then, a second coat of adhesive is applied to the top surface of the glass cloth to complete the impregnation and, when it is fully cured, a smooth, solid outer layer is formed. The same procedure is followed on the inside of the structure and the "sandwich" is completed. This method not only simplifies production considerably but leads to a lower-cost finished structure as well.

Thus, another year of growth within the plastics industry has stimulated equivalent research and development in its sister industry, industrial adhesive formulating. There is every indication that this interrelated growth pattern will flourish to the mutual advantage and profit of both.

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Consult the Subject Index for additional information concerning adhesives. See also the Adhesives Chart for information on properties and trade designations. For sources, see Directory Index, p. 1078.

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SOLVENT CEMENTING

By Irving Skeist[*]

Through trial and error, the following set of rules for cementing plastics have evolved:

1) The crystalline plastics are best bonded by heat rather than by adhesives (i.e., best adhesive is the polymer itself, melted).

2) Amorphous or noncrystalline plastics are bonded to themselves with monomers or cements—either solvent cements consisting entirely of solvents, or bodied cements, in which resins are dissolved in the solvents to thicken them, thus filling the spaces between poorly mating surfaces.

3) To minimize strains (and resulting stresses) caused by flexing or temperature change, the adhesive layer should be as thin as possible, and no more rigid than the materials being joined (the adherends).

4) Solvents and polymers for adhesives should be selected to correspond to the adherends in solubility parameter (SP). This may require the use of a two-layer adhesive if there is a big difference between the solubility parameters of the two adherends being used.

5) Low-boiling solvents give the fastest setting action, but are more likely to cause crazing. Crazing is most likely to occur with the more brittle plastics (polystyrene worst, acrylics somewhat better). To minimize crazing, avoid low-boiling solvents, or dilute them if used.

The highly crystalline, difficult-to-dissolve plastics such as 6/6 nylon, polyethylene, and the fluorocarbons are most readily bonded by heating them to a high enough temperature to destroy the crystallinity, then compositing with pressure while hot. The amorphous, easily dissolved plastics such as polystyrene and polymethyl methacrylate are most commonly bonded with adhesives which are liquid at the time of application but which lend themselves to the formation of a flexible solid interlayer through evaporation of volatiles or curing of a resin intermediate.

Vinyl chloride resins are fairly crystalline and are difficultly soluble in the unplasticized state. But with the addition of plasticizer (nonvolatile solvent), they become more amorphous and consequently more amenable to adhesive bonding by volatile solvents. Also, copolymers are more easily bonded than homopolymers.

The adhesive must be chosen with an eye to solubility parameter. The more polar plastics like nylon have high SPs while the less polar hydrocarbon and fluorocarbon plastics have low SPs. Each plastic material dissolves best in solvents whose SPs are about equal to its own.

Crazing

For styrene and acrylics particularly, the choice of a solvent cement poses a problem. The low-boiling solvents attack the plastic surfaces most quickly, permitting fastest assembly. But low-boilers also evaporate from the cemented piece most readily, leaving the joint in a state of stress which may be detrimentally relieved by crazing—the formation of many tiny cracks. Methylene chloride, highly volatile, softens polystyrene or acrylics quickly; but the polystyrene bond will craze in less than a month. Even without bonding, an injection molded piece may be sufficiently strained at the surface to craze when exposed to too active a solvent. Annealing at slightly below the softening temperature is of some help with acrylics, less effective with polystyrene.

High-boiling solvents and nonvolatile plasticizers, while slower to take hold, are safer. Perchloroethylene has been recommended for acrylics, amyl benzene for styrene. A low percentage of methylene chloride is permissible for quick starting.

Many different "cements" are

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[*] Director, Skeist Laboratories, 89 Lincoln Park, Newark, N.J.

used in bonding plastics. The resin manufacturers suggest the following compositions, among others, for bonding thermoplastics to themselves:

Polystyrene: toluene, perchloroethylene, xylene, or amyl benzene, diluted cautiously with methylene chloride for speed, and bodied with 10 to 15% polystyrene if necessary.

Acrylics: softer formulations are bonded with trichloroethane, harder acrylics with 90/10 methylene chloride/diacetone alcohol. For maximum joint strength and good weathering, it is best to soak the surfaces to be bonded in a 60/40 methylene chloride/methyl methacrylate monomer mixture which has been catalyzed by 0.2% benzoyl peroxide to cause the monomer to polymerize. Again, the cement should be bodied with a few percent polymethyl methacrylate if the surfaces are irregular, or if the acrylic plastic is to be bonded to acrylic-impregnated fabrics, as is now the case in aircraft canopy construction.

Cellulosics: solvent cements are generally mixtures of fast driers such as acetone and slower drying materials such as methyl Cellosolve or methyl Cellosolve acetate, or even nonvolatile plasticizers. For cellulose acetate a 70/30 acetone/ethyl lactate mixture is suggested; some of the acetone may be replaced by ethyl acetate. For cellulose acetate butyrate and propionate, a 70/30 acetone/methyl Cellosolve acetate mixture is effective. The cements may be bodied with cellulose esters, or with the more strongly adhesive cellulose nitrate if the cellulose ester plastic is to be bonded to a different material.

Vinyls: the following formulations are suggested for the bonding of rigid vinyl sheet to itself. Both are based on methyl ethyl ketone (MEK), plus a small amount of acetic acid for better "bite." The first contains a small amount of high-boiler and nonvolatile plasticizer, while the second cement is bodied with a ketone-soluble vinyl chloride-acetate copolymer.

Solvent cement: 63% MEK, 20% dioxane, 10% methanol, 2.5% dioctyl phthalate, 2.5% isophorone, 2% acetic acid.

Bodied cement: 96% MEK, 2% VYNS resin, 2% acetic acid.

The strength develops as the solvent evaporates over a number of hours.

Characteristics of final bond

Solutions of polymer in organic solvents give good bonding. The characteristics of the final bond, after all solvent has been removed, are predetermined by the known properties of the polymer base. Unless at least one of the adherends is porous, all the solvent must be evaporated after the adhesive is spread on and before the surfaces to be bonded are joined together, since negligible solvent will be absorbed by the adherends. In such cases tackifiers may have to be added to the cement to get good adhesion of the evaporated coated surfaces, and they may reduce the unit strength of the finished bond.

WELDING-SEALING-FASTENING

The subject of assembling plastics products continues to grow in importance to the plastics industry—particularly as plastics materials move more and more into larger pieces and more complex units. The data below, obtained from a number of sources, outline some of the other new assembly techniques.

SPIN WELDING[1]

Spin-welding is a unique fabricating method that is especially well suited for joining thermoplastics. The technique employs frictional heat that is generated by the rotational rubbing of two contacting surfaces to produce joints having exceptional quality and strength.

Specifically, the spin-welding process involves rotating one section to be welded in a powered spindle against another part which is held stationary. Rubbing contact is maintained at a speed and pressure which generates frictional heat and melts the adjacent surfaces. When sufficient melt is obtained, pressure is increased to squeeze out all bubbles and to disperse the melt uniformly between the weld faces. The stationary part is then released, or the powered spindle stopped, halting the rubbing action and allowing the weld to form. Pressure is maintained until the weld sets up.

In addition to the advantage of the outstanding quality of the welds produced by this technique, spin-welding offers economic advantages through speed and simplicity of operation. Standard machine shop equipment, such as lathes and drill presses, may be adapted for most spin-welding jobs. With the aid of jigs and fixtures, standard equipment may be converted to production units capable of joining sections with only seconds of welding time.

The frictional heat generated by spin-welding is of such intensity that it produces almost immediate surface melting while the temperature of the material immediately beneath the surface remains relatively unchanged. For many applications, no surface preparation is necessary. A rough saw finish, in fact, can be welded into a joint of similar quality to that obtained from a machined surface.

One disadvantage of this technique is in the limitation of joint shape. The required circular shape may, however, be designed into a non-circular part and the spin-welding apparatus may be indexed to align the nonuniform part into the required final position. A possible second disadvantage is flashing which is sometimes necessary to insure complete welding. However, joint design may be regulated to minimize this flash or to trap it in internal recesses.

HEAT-SEALING[1]

The basic principle of heat sealing—electronic welding—is a simple one: as waves from a high-frequency generator pass through, the molecular friction generated in the plastic heats and melts the material, whereupon pressure brings about thorough fusion. As the material solidifies, a complete weld is achieved. This bond, properly made, is at least as strong as the material itself. (For a technical review of the process see "Electronic heat-sealing," by Robert D. Farkas, MPL, March 1958 p. 109)

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[1] From a paper "Joining plastics parts," presented by A. J. Cheney and W. E. Ebeling, (E. I. du Pont de Nemours & Co., Inc.) at the 14th SPE Technical Conference.

[1] Adapted from "Hot subject: heat sealing," Modern Plastics 35, 85 (April, 1958).

The major material thus far to take advantage of the speed and economy of heat sealing has, of course, been vinyl. Today, such basic industries as furniture and automotive are designing many products specifically to take advantage of dielectric heat-sealing.

Among the most interesting recent developments in electronic welding have been the heat-sealing of plastics other than vinyl. Foamed vinyl, of course, behaves just like sheeting and has never presented any sealing problems. More recently, acetate and butyrate have been heat-sealed, a potentially far-reaching development because these materials are the backbone of blister packaging.

Now, on the forefront of electronic welding technology, four other plastics—all of them with desirable properties—are being successfully welded to themselves. 1) Polyurethane foam, where heat sealing can become an indispensable production method for many end products. 2) Fluorocarbon film is being welded in preparation for a commercial packaging application, in which the film will be used to hold individual hypodermic shots in transparent containers heat-welded at both ends. 3) Nylon film can also be welded. It is temperamental, but with care an excellent seal can be obtained. The chief idiosyncrasy of nylon film is that the best seal is the one made in the shortest time. This is not surprising, considering the fast transition nylon makes from solid to liquid at melt temperature. 4) Some polyester films have been electronically welded. All the problems have not yet been worked out, though they promise to respond to study.

Improved techniques

Though the welding of newer materials is of great interest, the improved techniques worked out for vinyl—the bread-and-butter of electronic welding—are more important to the field. The technique of tear seal appliqué, introduced a few years ago, has blossomed both in terms of technical improvement and commercial usage. It is a method whereby three-dimensional designs in three colors can be applied to a base sheet of vinyl of a different color in a single operation. By this method, it is possible to duplicate trademarks exactly, in full color, and dress up any vinyl article by adding color to it.

Of great value for some applications is the slip-sheet technique, a trick of the trade which takes advantage of one characteristic of polyethylene generally considered undesirable; the fact that it cannot be sealed electronically. In slip sheeting, a layer of polyethylene is used to separate two layers of vinyl over areas between which a seal is not desired. With the process, flatter, more comfortable air mattresses, with less strain on the welds, are being manufactured.

The same method, applied to the manufacture of large tarpaulins and industrial covers, speeds up production by putting several layers of material under the electrode at the same time, thus making joints at once.

Another special technique is the "drape" method, whereby two seals can be made simultaneously at both ends of a long sheet of material. The press is designed to allow a large billow of material to drape down in the center, while the ends are placed under the sealing electrodes. This method has been employed to make complex seals on both lateral ends of an automobile seat cover at once.

MECHANICAL FASTENERS[1]

Mechanical fasteners are also adaptable to the job of assembling plastics products. Many standard devices now in use with metals, woods, or other materials are equally applicable to plastics—provided, of course, that the design engineer takes into account some

TABLE I: Equipment capacity for heat sealing[1]

Plastic film, total thickness	*½ kw.*	*1 kw.*	*3 kw.*	*5 kw.*
0.008	1.2	2.0	6.0	13.0
0.112	1.6	3.0	8.6	17.5
0.016	1.8	3.5	10.2	20.5
0.020	2.0	4.0	11.4	22.3
0.024	2.2	4.2	12.4	24.6
0.030	2.4	4.6	13.6	26.7
0.036	2.5	4.9	14.5	28.8
0.040	2.6	5.1	15.1	30.0
0.060	2.8	5.6	16.8	34.0

[1] Prepared by N. S. Beekley, Jr., Chemical Materials Development, The Goodrich Tire and Rubber Co., Akron 16, Ohio.

NOTE: Figures in the body of the table indicate the sq. in. area of actual welding surface that can be handled by generators of the sizes listed.

For example: To seal two thicknesses of 0.015 in. vinyl film with a 3 kw. generator, the maximum seal area possible is read from the table as 13.6 square inches.

Conversely, to determine how to seal a card case, where the total seal area measured on the finished part is 3.1 sq. in.: The material making up the card case is one layer of 0.012 in. and one layer of 0.006 in. vinyl. Total thickness is 0.018 in. or approximately 2 × 0.008 inches. Nearest area to 3.1 is 3.5 in column head 1 kw., so a 1 kw. generator will handle the job.

The figures in this table are based on the use of *good first-grade virgin vinyl films;* electrodes made from either brass or steel, operating at production temperatures; and sealing times of 4 sec. or less.

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[1] Material in this section is adapted from data appearing in the S.P.I. Plastics Engineering Handbook (Reinhold Publishing Co.) from a paper on "Joining Plastics Parts," presented by A. J. Cheney and W. E. Ebeling (Du Pont) at the 14th S.P.E. Technical Conference and from information supplied by Tinnerman Products, Inc. (spring steel fasteners), United Shoe Machinery Corp. (blind rivets), and Geissel Mfg. Co. (hinges).

of the special problems peculiar to plastics materials; e.g., their response to localized stresses.

1) Threaded holes can be molded or drilled in a plastic piece and conventional machine screws used. The technique is especially useful when limitations of wall thickness obviate other methods. It does, however, often require an extra finishing operation and, with some of the more fibrous plastics, threads are sometimes imperfect.

2) Metal self-tapping screws (which are removable and replaceable) and metal drive-in screws (which cannot be replaced once they are removed) can also be inserted into molded or drilled holes in the plastic. The displacement type of self-tapping screw is recommended for thermoplastics; the thread-cutting, pitched thread screw, such as the Type F, offers optimum performance with nylon, acetal, and acrylic. Variations are also available for use with the more friable thermosets, or where strains must be minimized.

3) Where necessary, molded-in inserts to receive the screws can be used to effect more permanent assemblies or to add to the life of the screw thread.

4) Spring steel fasteners (which can be in the form of simple clips, tubular devices, or irregular shapes) also find use in the assembly of plastics products. Spring steel can harness cold flow tendencies of plastics materials by gripping the plastic under firm live spring tension that gives and takes with the plastic action. Spring steel will yield enough to permit a safe assembly, then firm up to give positive, vibration-resistant attachment that eliminates the danger of breakage and high scrap loss.

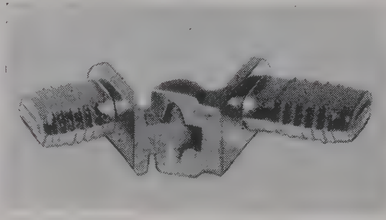
One popular method for using these fasteners is to provide integral studs that accept fast-acting fasteners which slip into place. Cavities and protrusions in the molding also offer fastening points for self-retaining fasteners.

5) Industrial blind expansion rivets are fast-acting, one-piece fasteners similar in function to ordinary solid rivets, but are especially adaptable in blind riveting and in hard-to-reach fastening jobs. In one such type of rivet, assembly consists of placing the rivet in a drilled, punched, or molded

Three new thread-cutting screws designed to reduce pressure development by 80% have been introduced (Parker-Kalon). One has tapping flutes that cut a standard machine screw thread as the screw is turned in (for use in friable, granular, or brittle materials). In the second, thread-cutting flutes with coarse pitch and widely spaced threads, are designed to let chips drop to the bottom of the hole while distributing cutting pressure evenly (for use in making fastenings to comparatively thin sections and bosses in friable and brittle plastics). The third was developed for use in nylon; it functions as a combination thread-cutting and thread-forming screw, in that it cuts a small amount of nylon to allow full diameter threads to form. It can be removed from the assembly and replaced without stripping or galling.

• • •

Using a new casting process (*Intercast,* Gries Reproducer Corp.), special hinges for eyeglass frames can be automatically cast. The design of the new hinge facilitates speedy one-step assembly of the eyeglass frame. A single press stroke anchors harpoon-shaped teeth of studs into mating holes which are molded into the temples and frontpiece.



HINGE for eyeglass frames

• • •

A manufacturer of reinforced plastics boats (Holiday Plastics, Inc.) has put rivets and adhesives to use in solving a joint design problem for attaching the deck to the hull of a 14 to 16-ft. runabout. . . . The joint is first laminated by placing 1-in. wide strips of polyester resin-impregnated fibrous glass on the hull section. The deck is then placed over this material and clamped in position by a series of screw-jack clamps. While held, ¼ in. holes are drilled at predetermined distances (10 in. on center) in which the rivets (*POP*) are placed at the time of drilling. Following the operator who drills is another who sets the rivets with the air-pressure gun immediately following drilling. As soon as all the rivets are set, the clamps are removed and the rivets secure the deck to the hull during the 30 min. curing period. The net result is a 25% reduction in man-hours required in the fastening operation.

• • •

The thread of a new set screw (*Zip-Grip,* Set Screw & Mfg. Co.) actually locks at any point securely, regardless of vibration, and does not have to contact the shaft. It is especially useful on adjusting or metering screw applications. A standard class 2 tapped hole is all that is required. The set screw can be used over and over again in the same tapped hole or can be replaced by a regular set screw.

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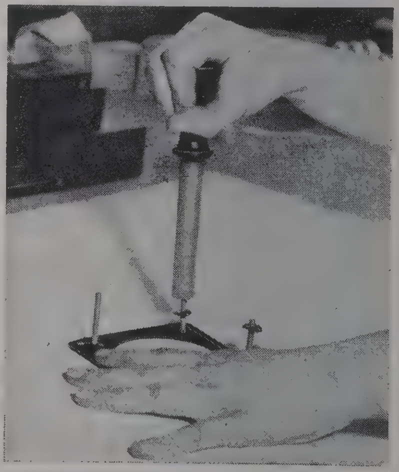
Spring steel fasteners (by Tinnerman Products, Inc.) figure in several assembly case studies:

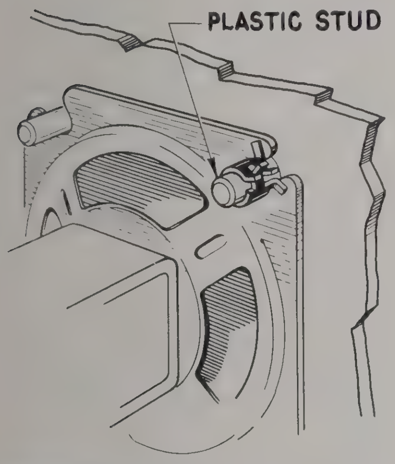


PUSH-ON FASTENER being applied

1) A metalized control panel is fastened to the top cover plate of an automatic dishwasher with push-on fasteners (*Speed Nuts*).

Integral studs molded into the panel provide the mounting surface. In this case, an extra generous base arch in the fastener is provided to give greater resiliency and more take-up on the studs. This tends to offset surface irregularities over the width of the cover plate due to normal distortion and porcelain build-up. See photo on facing page.

2) A thin-walled plastic face plate is equipped with corner studs quickly and simply with special spring steel fasteners (*Zip-on type Speed Nuts*). These special thread engaging fasteners have prongs with a helical pitch to match the screw thread. The resilient prongs are started over the stud, then zipped down to the bottom—a turn or two for final locking and the stud is firmly in place for final assembly.



SPEAKER secured to cabinet

3) The speaker on a clock-radio is secured to the plastic cabinet with special tubular-type fasteners (*Speed Clips*). Once the speaker is in position, the fasteners are expanded by squeezing the spring fingers together with a pair of pliers. This increases the diameters of the clip and permits it to be slipped over the plastic mounting studs. (See drawing, above.) When released, the fasteners close down on the stud with firm, rattle-free, spring pressure. The fasteners can be easily removed when servicing is required.

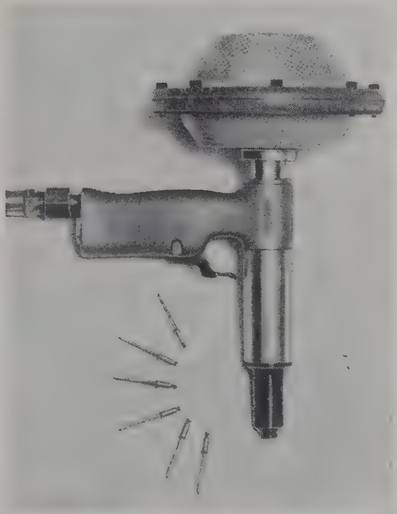
4) A plastic sign maker used spring steel fasteners to cut assembly time and costs by 48 percent. Self-retaining moulding clips for the perimeter trim were first snapped on the plastic face. Self-retaining "J" type nuts on the rear mounting flange were used for the rear service cover and special flange spring clips locked the two halves of the sign together.

• • •

Knurled inserts (from Southco Fasteners) can be pressed or molded into plastics. The deep spiral knurling takes a firm grip in a drilled or molded hole, resisting both torque and pull-out. Screws are easily installed and guided into place by the insert's counterbore. Where an unblemished surface is required, the insert can be driven into a blind hole from one side of the job. This type of insert can also be used with a through hole, providing a set-up where a bolt can come in from the opposite surface to engage with its threads.

• • •

A new type of portable riveting gun that weighs less than 4 lb. and is priced under $100 is being made available (POP Rivet Div., United Shoe Machinery Corp.) for use with *POP* rivets. . . . It operates off plant air or in-field air compressors.



NEW TYPE portable riveting gun

hole. The heated tip of a riveting iron is then applied to the rivet head. The charge in the rivet changes to a gas, expanding the shank to fill the hole. When expanded, the shank of the rivet forms a barrel-shaped head on the opposite side of the work to lock it in place.

More recently, the development of a new type of blind rivet, together with simplified techniques and tools, has stimulated interest in riveting as a popular means of assembling plastics products.

The rivet in this case (as made by POP Rivet Div., United Shoe Machinery Corp.) consists basically of a headed, thick-walled hollow cylinder and an internal mandrel with a preformed notch. When the mandrel is pulled by the riveting tool, it upsets the rivet, squeezes the sections together with a tight clinch, and breaks at a predetermined setting force. There is no impact to break the base plastic.

The equipment for accomplishing the job with these rivets is relatively inexpensive while the rate of assembly (riveting cycles well in the hundreds have been reported) is fairly high. The technique can also be used for joining plastics to metal, porcelain, wood, or leather. And, of course, the rivets can be assembled blind or in areas having minimum back-up clearance. The rivet is inserted in the mating holes and the gun is placed over the mandrel and cycled.

Various types of plastics rivets have also proved themselves applicable for joining plastics parts together. In one type, the rivet consists of a hollow body and a solid pin. The rivet is placed over the point of joining; a sharp blow drives the pin from the plastic collar and into the hollow shank where it sets up a positive locking action.

Metal rivets have also been used occasionally with high-impact plastics.

6) Hinges[2] also play a role in assembling plastics products. Generally, the hinges are designed with sharp teeth along the sides that lock them into position.

Most hinges are set into place in molded-in slots and pressed into position with an arbor press. The production rate can generally run up to 200 to 500 pieces/hr., depending upon the particular job. Most of the hinges are custom designed to meet the requirements of a special job. They can, for example, be designed with protruding ears that help lock them permanently in place, or, where necessary, they can be supplied with C-springs that allow the hinged parts to be held in an open position. Users of hinges should check with suppliers first.

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[2] Data supplied by Geissel Mfg. Co.

While many fastening devices are made of metal, mention should be made of molded plastics fastening devices which are beginning to find widespread use. The use of a plastic fastening device in a plastic assembly maintains the concept of an "all-plastic" construction with no weak spots liable to corrosion or chipping or which do not offer the same degree of electrical insulation, etc., as the rest of the product. Several manufacturers, to obtain the advantages of both materials, have experimented with fasteners based on a combination of metal and plastics parts.

One manufacturer (Gries Reproducer Corp.), for example, offers a line of metal fasteners with molded-on plastics heads. This enables the user to gain the mechanical property advantages of the metal and the electrical property advantages of the plastic at low cost.

MECHANICAL DEFLASHING AND FINISHING

By R. E. Leliaert* and L. D. Stevens†

The application of established metal cleaning and finishing processes to the deflashing and deburring of plastics parts can result in substantial savings in time and labor. These processes involve the use of airless blast deflashing and barrel finishing (tumbling) equipment.

Most plastics, both thermosetting and thermoplastic, can be successfully deflashed as well as finished and polished by tumbling. Deflashing in airless blast equipment, however, is usually limited to compression or transfer molded thermosets, although some of the laminated materials can be deburred by this method.

Airless blast process

Deflashing by airless blast consists of bombarding molded parts with millions of nonabrading tiny pellets which break off the flash by impact. The equipment required for airless blast deflashing consists of four principal components: a rapidly rotating wheel for hurling the pellets (Fig. 1, right); a work conveyor for efficiently moving or gently tumbling the parts through the blast area; a pellet recycling system; and a dust collector.

If the flash thickness is kept under certain limits (about 0.008 in.) by proper mold design and maintenance, parts of highly complex design can be deflashed rapidly in this type of equipment.

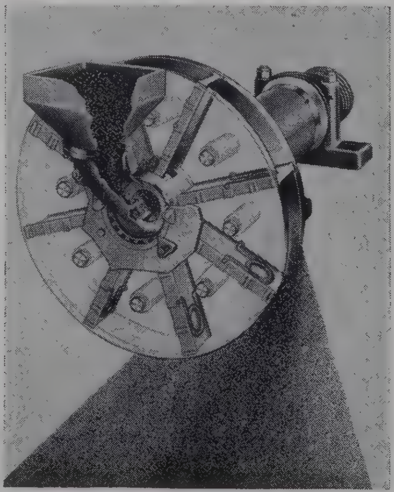
Pellets which have given the best results in airless blast deflashing are agricultural products such as crushed nut shells or fruit pits. They have enough mass to be propelled with sufficient energy to break off the flash or burr but are not so massive or sharp as to break, nick, or scratch the molded part. Parts with metal inserts can be deflashed without damage to plated or other highly finished surfaces on the inserts.

Batch-type equipment

Most of the airless blast equipment now in use for plastics deflashing is of the batch load type. In this type of equipment (Fig. 2) an endless rubber belt within a chamber tumbles the work in the blast pattern. This type of equipment is especially useful in deflashing large volumes of small parts and is applicable to parts of virtually any size that are not too thin or fragile to withstand the gentle tumbling action.

In batch-type machines, the spent pellets fall through holes in the conveyor and drop into the boot section of a belt and bucket elevator. The elevator carries the pellets and small flash to an overhead cleaning separator and storage hopper from which the pellets are fed back to the blast wheel.

FIG. 1: Airless blast wheel for deflashing plastics parts. Pellets from hopper are hurled from ends of wheel blades



Fragile pieces

For thin, fragile, or large parts that cannot be tumbled, table-type equipment (Fig. 3) is available for airless blast deflashing. Parts in this category include radio cabinets, terminal blocks and cases for cameras, etc. If the part to be deflashed must be blasted on both sides, the part can be run through the blast, turned over, and run through again.

In table-type machines, individual tables carry the parts through the blast zone. These tables also rotate so that all upper areas of the work are adequately exposed to the deflashing action.

Adjustments for control

If test runs of certain parts indicate that chipping or breakage may be a problem, adjustments can be made: 1) slowing the drive on the batch-type work conveyor to provide a more gentle tumbling action; 2) reducing the size of the load; 3) adding short lengths of rubber hose to the load; or 4) reducing the speed of the throwing wheel to lessen the impact of the pellets. The latter would hold true for both batch or table-type deflashers.

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*Application research engineer, Wheelabrator Corp., Mishawaka, Ind.
†Plant mgr., Techline Div., Wheelabrator Corp., Vicksburg, Mich.

Although the mechanical nature of the process makes possible the high speeds of production needed for volume deflashing of many plastic parts, this method is obviously inapplicable when any section of the part is thinner than the flash to be removed.

As a general rule of thumb, flash thickness should be no more than 0.006 or 0.008 inch. Good mold design and proper mold maintenance can certainly limit the flash to this thickness. Although flash can be removed up to a thickness of 0.010 to 0.012 in., this usually results in a rough parting line.

Mold design

The importance of mold design to deflashing operations cannot be overemphasized. Many difficulties encountered in attempting to reduce finishing costs can be eliminated at least cost by simple change in mold design.

For example, sharp corners are susceptible to chipping. If the corner can be rounded, this source of potential trouble is eliminated. In certain instances, chipping is a problem only if it occurs on an exposed surface. Perhaps something as simple as changing the direction or location of the parting line will hide any chipping that does occur without reducing the utility of the part.

Another special problem that has been overcome is the tendency of flash to adhere to the metal surfaces of inserts. If the exposed portion of the insert is dipped into a solution containing wax or colloidal graphite before placing it in the mold, adhesion of the plastics to the metal will be reduced, as will also the blast time required.

Operating costs

Operating costs of this type of equipment are very low. It is difficult to predict an average total operating cost because of the variables present in any deflashing job; however, in most cases the hourly cost is less than 50¢ per hour. With the usual operating cycle for a batch-type machine for loading, deflashing, and unloading varying from three to 12 min. per load, the average cost per load is only a few cents.

Labor costs are also low because of the simplicity of the operation as well as its high production capacity. In one case, a machine costing approximately $7000 effected savings of as much as $100,000 in direct labor costs in the first year's operation. In another company, direct labor costs were reduced $110 a day in deflashing molded electrical insulating parts.

Barrel tumbling

Another economical, mass-production method for removing flash and burrs from plastics parts is tumbling in barrels. This procedure can also be employed to impart a certain precision finish, to radius edges, and to polish to a specified luster.

Whether the desired end result is the removal of flash and burrs, finishing, or polishing, all tumbling procedures involve basically the same factors—impact and abrasion. The work pieces are charged into the barrel, together with whatever tumbling aids and/or polishing compounds are needed for the job to be done. As the tumbling barrel rotates around a horizontal (or practically horizontal) axis, the resulting abrading action is complemented by impact between the work pieces and other material in the barrel. Both the abrasion and the impact contribute to deflashing and deburring. Radiusing, finishing, and polishing result primarily from the abrasion of tumbling media and compounds on the plastics parts.

Deflashing by tumbling

Some tumbling is accomplished without added media and depends for its effect on impact and abrasion between the work pieces themselves. Such pieces are described as "self-tumbled."

Coarse deflashing can be accomplished in this manner. In dry self-tumbling, a wire mesh barrel can be employed in which the wire mesh openings are sufficiently large to allow broken flash to drop out. Cycles of more than 90 min. are usually not required in this type of operation. The addition of smooth blocks of wood in suitable sizes may be helpful in removing excessively heavy flash.

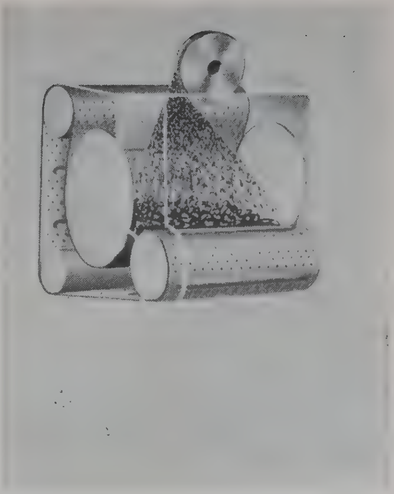
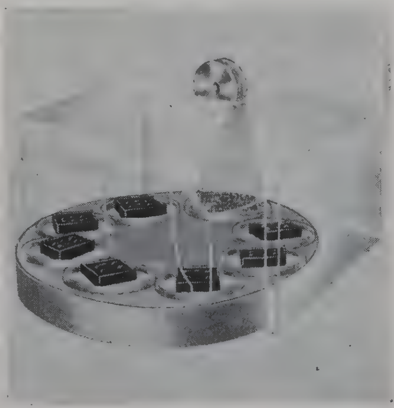


FIG. 2: Tumble-blast deflasher, in which work pieces are tumbled while subjected to impact of flying pellets, is illustrated in cut-away drawing above.

For final removal of flash lines and for deburring, wet self-tumbling with a tumbling compound is usually indicated. Rubber-lined steel barrels at least 30 in. in diameter should be used. The recommended load ranges from 50 to 70% of the volume of the barrel and water is added to a level of 2 in. above the mass. Flash and burr removal which is accomplished by the use of wet self-tumbling usually requires a cycle of approximately 30 to 45 minutes.

Wet tumbling with aluminum oxide chips goes a step further than deflashing and deburring. With such chips, it is possible to radius edges according to specifications, remove flash lines and burrs, and improve surfaces of the parts which are being processed.

FIG. 3: Table-type deflashing machine in which individual tables, on rotating wheel, turn to expose all sides of the parts to airless blast



Neoprene-lined barrels are used with this method.

When work pieces contain areas which are hard to reach, steel pins, balls, or shot can be used in wet or dry tumbling, although wet tumbling usually is better. A deburring or burnishing compound to help cushion the impact of the pins and balls should be used.

Barrel finishing

Where finishing in the form of surface grinding is required beyond the removal of flash and burrs, tumbling barrels can be used with finishing balls (made of wax and a fine abrasive) and pumice granules. Aluminum oxide chips can also be used for this purpose, but the finishing balls and pumice granules have a gentler action.

Finishing granules are often used on such parts as buttons and eyeglass frames and also have proved useful for putting a matte finish on surfaces of keys used on typewriters and other business machines. Such finishing can be accomplished in simple wooden barrels.

Tumble polishing

For polishing, the tumbling barrel should be airtight with a hardwood liner. Specially developed creams are used for imparting high, permanent luster to plastics parts. Wooden carriers, such as hardwood shoe-pegs, dowels, or cubes, are required with these creams. The polishing cream, with thinner, is always poured on the carrier, which then is rotated to coat the wooden media with the cream. The cream never is put directly on the pieces to be polished.

Tumbling costs

With simple, easily established maintenance programs, operating costs for tumbling equipment are low. Most media can be used several times, so that original investment becomes nominal in terms of work performed. The tumbling action is so gentle that little maintenance of barrels, liners, and other parts of the equipment is required. Labor costs per piece are almost negligible because of the large volume of parts handled per man-hour.

DECORATING MOLDED PLASTICS

Virtually every type of molded plastic can be decorated in one way or another. The methods available are many and versatile enough to meet various combinations of appearance, costs, or production speeds required.

Covered below are some of the more popular basic methods, how they are used, and what the potential user should know about them before attempting to adapt them to his special needs.

VACUUM METALIZING

By John Scharnberg*

Vacuum metalizing of plastics falls into two major categories, functional and decorative, with subcategories of first surface and second surface, or backside, application.

An example of first surface functional application might be the reflecting side of a flashlight reflector. Decorative first surface application could include such objects as metalized toy cap guns. A second surface decorative application is one in which the metalized surface is viewed through the clear plastic—e.g., the escutcheon of an auto horn button.

The most commonly used metal in vacuum metalizing on plastics is aluminum. Relatively easy to evaporate it has about the same color as polished chrome. With a top coat of lacquer, it can be dip dyed to simulate any metallic color.

Metalizing process

To describe the metalizing process briefly, the parts to be vacuum metalized are first lacquered. This coat is referred to as the base coat. When the base coat is properly cured or free of volatile solvents to the extent it will not outgas, the parts and the fixtures they are mounted upon are placed in a vacuum chamber. In the center of the vacuum chamber are strands or coils of tungsten wire filament; aluminum staples are hung on these coils. The filaments are connected to several electrodes running lengthwise to the axis of the vacuum chamber. (In this case, we are speaking of a horizontal vacuum chamber as opposed to a vertical bell.) The number of filaments used depends upon the type of metal to be deposited and the degree of uniformity desired. The pressure in the chamber is reduced to 0.5 microns or lower and the filaments are heated to incandescence at 1200° F. The aluminum melts and spreads evenly over the tungsten filaments. The temperature is raised to approximately 1800° F. and the aluminum evaporates. This evaporation or flashing takes from 5 to 10 seconds. During this period, all parts that are exposed or in direct line to the evaporated aluminum receive a thin deposit of aluminum. The parts are now removed and given a top or protective coat of lacquer.

The function of the aluminum is to provide both reflectance and opacity. Since an aluminum film thickness of 1/300,000 in. will provide opacity, the cost of aluminum is negligible. One pound will cover approximately 25,000 sq. feet.

After aluminum, the second most commonly used material for commercial evaporation is a copper alloy consisting of 88% copper, 10% aluminum, and 2% nickel. This alloy furnishes a color which is similar to that of 24 kt. gold.

The base coat

The base coat may be applied by either spray, dip, or flow coating techniques. It should have the following characteristics:

1) Good adhesion to the plastic.

2) Solvents which will not attack the plastic should be used.

3) A solids content sufficiently high to cover minor scratches and to supply a good polished base for the metallic deposits. The better the base coat hides these minor flaws and imperfections, the higher the gloss or re-

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*Mgr., New Product Development, Bee Chemical Co., Logo Div.

flectance of the metalized surface.

4) Cures in such a manner so as to not distort the molded piece. In the case of most thermoplastics, curing temperatures of 140° F. for short periods of time are about as high as you can safely go.

5) The formula must be so balanced that it will dry smoothly and rapidly without showing sags, craters, or drips.

6) Depending on the plastic, it must be an effective barrier to minimize outgassing during the metalizing operation.

7) It must allow the aluminum to have good adhesion to it and, in the case of second surface applications, have dried film clarity.

8) It must produce consistent results in production.

These requirements are general. Under certain conditions, the coatings may also be required to withstand salt spray, humidity, etc.

It is not true (although often stated), that some solvent action, (often called bite), on the plastic is necessary for good adhesion of the coating. It is true, however, that each type of plastic may require a different solvent blend which must not only prevent crazing, but also allow for proper flow-out and homogeneity of film.

The top coat

The top coat is a protective coat. This, too, can be applied by different techniques, but it should have these properties:

1) Good adhesion to the metalized surface.

2) Provide a finish of high gloss and transparency.

3) Should not discolor or impair light reflectant properties of the aluminum coating.

4) Cure or air dry in a sufficiently rapid manner so as not to hamper production.

5) It should be scuff- or abrasion-resistant.

These requirements are general. In many instances, additional properties are required.

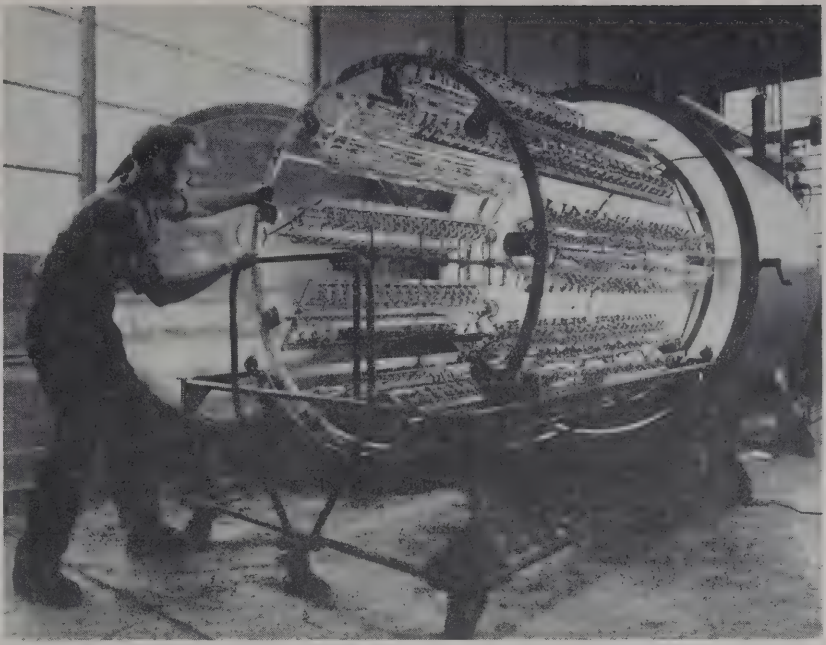
Acetates

Cellulose acetates are not commonly vacuum metalized by the batch or job shop operator, but proprietary items of acetate are being vacuum metalized.

An evaporated aluminum coating will adhere to acetate; however, drawing a high vacuum on a bare or uncoated acetate presents several problems because of the plasticizer which is added to the polymer to facilitate processing or to increase flexibility or toughness. These problems become more serious ones to deal with as the amount of plasticizer is increased.

When a high vacuum is being drawn, the plasticizer begins to outgas. Outgassing increases with rising temperature and diminishing pressure. On short runs, some people preheat and outgas the parts and then cool them before beginning vaporization of the metal. Outgassing is expensive, in that it causes a long draw-down time; also, these vapors contaminate the equipment and interfere with uniform deposition of the aluminum plate. The efficiency of the vacuum unit gradually lowers until the machine requires cleaning with solvents.

A problem with applying a base coat to the acetate (in this case we should refer to it as a barrier coat) is to prevent the plasticizers from outgassing. If the base coat or barrier coating that is used will not allow the plasticizer to migrate into it, there is a possibility that small blisters may eventually show on the surface of the part. If the plasticizers are allowed to migrate into the base coat, there is a possibility that they will cause a loss of adhesion, tackiness, or softness of the film.



RACK OF PLASTICS PRODUCTS TO BE METALIZED is rolled into vacuum chamber, shown at right in above picture, where they will be surfaced with aluminum. (Photo, NRC Equipment)

Butyrates

The problem of cellulose acetate butyrate is similar to that of the acetates, but not to the same degree. The pellets supplied to the molder usually have plasticizers incorporated within them. Depending upon the amount of plasticizer incorporated, the butyrates are classified as soft, medium, and hard flows. The harder the flow, the less the plasticizer incorporated. It is important to use the hardest flow consistent with good performance of the finished article. Unfortunately, some compromise may be necessary to obtain required impact resistance. Where the manufacturer of the butyrate knows that the parts are eventually to be metalized, he can omit such additives as ultraviolet inhibitors and volatile color agents which, when they are employed, will tend to increase the outgassing.

Cellulose acetate butyrate requires much less plasticization than straight acetate, as it is inherently more flexible. It is also compatible with, and has better solubility in, a greater number of plasticizers, thus giving the formulator an opportunity to reduce the danger of plasticizer migration.

Acrylics

Acrylics do not present a similar problem for vacuum metalizing, as there is no plasticizer problem. Acrylics are usually vacuum metalized when second surface properties are required.

An example of an acrylic application is the escutcheon attached to the front of many automobiles. It may be second surface metalized with tinted base coats and an opaque back-up coat. Whereas previously these materials were enclosed in a bezel and mounted to the metal, they can now be bonded directly with adhesive. This vacuum metalized second surface application, when bonded to clean steel, produces a shear strength of from 175 to 250 p.s.i.

Polyethylene

For the purposes of vacuum metalizing, there are two types of polyethylene, treated and untreated. There has been some vacuum metalizing of untreated polyethylene; however, this field is not promising at the present time. Permanent adhesion of the base coat over a period of time has been difficult to obtain. Somewhat better results are secured by plating on treated polyethylene, especially on small parts.

Phenolics

With the advent of vacuum metalizing, a phenolic casting can now be made to look like a chrome-plated metal die casting and be almost as serviceable, at a considerable reduction in cost. One-stage phenolic ordinarily is more difficult to mold, but in the case of bottle caps and closures, these are simple forms and present no serious problems. Two-stage phenolics are a more versatile material for the molder to use. He can run large parts with fewer problems in his molding operation. However, the outgassing of these materials after they are molded can cause the vacuum metalizer trouble. In most cases, he will have to use a base coat that is unaffected by the amines which are released by the two-stage phenolics when they are raised to elevated temperatures. Some companies engaged in vacuum metalizing have encountered difficulties working with phenolics without realizing that two types of materials—one-stage or two-stage—are involved.

Further, there is a difference between various molding compounds. The phenolic resin is often compounded with a filler to lower costs and to better the control of some of the properties. Plasticizers and internal lubricants may also be added to assure proper mold release of the hard articles from the mold. These variables, if unknown, are possible causes of failure on the part of the vacuum metalizer.

The molding shop itself is another possible source of trouble. The molder usually allows the part to cure a short time before removing it from the mold. If the molder shortens his cycle, then the vacuum metalizer has to preheat and continue the cure prior to applying his base coat.

Occasionally, the molder will incorporate a rubber to provide the molding composition with special properties, such as high resistance to shock, or to obtain a quicker cure. If these parts are undercured, there is a possibility that when the base coat is applied by the vacuum metalizer, the part may continue to cure. In this case, the metalizer will have a hazing of his plate, generally noticed after the top coat has been applied and cured. As with every other plastic part being vacuum metalized, contamination by the mold release employed or by the cleaning solution is also a problem.

Polystyrene

Polystyrene is somewhat difficult to handle from the coating end. It is easily attacked, to the point of surface wrinkling and crazing, by almost all organic solvents with the exception of the alcohols and some aliphatic hydrocarbons. It is especially sensitive to the aromatic hydrocarbons. This unusual solvent sensitivity is a big obstacle and the choice of base coats and top coats becomes rather limited as a result.

Further, there are various grades of polystyrene that will tolerate different amounts of active solvents before crazing. On some parts, even different sections of the same mold will craze more easily than other sections due to the difference in stresses on the surface of the plastic. Also, mold release agents are very often used. They are either incorporated into the plastic as an internal lubricant or applied to the surface of the mold. Many of these mold release agents, as in the case of the zinc stearate, can be wiped off, but in the case of waxes and silicones, they are extremely difficult to remove from the surface.

Vacuum metalizing on polystyrene with aluminum is often referred to as too gaudy or bright or not truly representative of chrome plate. In the toy trade, this brilliance is an advantage. In the automotive trade, the top coat has a very slight amount of blue dye incorporated with it. In this manner, the gloss is maintained, the brilliance reduced slightly, and the blue tint gives a color match for the chrome plate.

Polyesters

Fibrous glass-polyester resin moldings can be vacuum metalized when premix molded in matched metal or compression molds. Parts made by bag molding or laminating are likely to outgas air in the vacuum chamber, causing blisters and craters in the base coat.

Parts molded of premix materials, of course, also have mold release problems.

Golds

In vacuum metalizing, brilliant golds can also be applied to plastics. There are three commonly used techniques to obtain this effect:

1) To vacuum plate in the usual manner, and after the parts have been plated with the aluminum and a top coat applied, they are dip dyed. A dip dye gives a smooth application and uniform coloring. It has a disadvantage, however, from a cost standpoint, in that it is an additional operation. Coatings that will accept a dye are usually low in other physical properties.

2) A second solution is to plate with copper alloy or metallic gold instead of aluminum. This eliminates additional operations and gives a durable gold appearance;

however, it has a disadvantage in that the available color range is limited and, particularly when evaporating the gold-colored alloy, the color is difficult to control. If the color is to be matched very closely, a third system is often used, as follows:

3) The top coat has the tint incorporated in it and is usually a custom-made material that will give the exact shading required. These golds are usually transparent and pick up their brilliance from the aluminum underplating. Advantages include control of color and the elimination of additional operations. A disadvantage of the technique, in the case of irregular surfaces, is the possibility that there is too much or too little color in specific areas.

Equipment problems

If the aluminum coating is translucent, the problem could be:

1) The period of aluminum evaporation is too short. The solution would be to leave the rheostat turned on in a higher range for a longer time, but care must be taken to prevent overheating of the plastics parts.

2) The pressure in the vacuum chamber may be too high. This pressure should be 0.5 micron or less at the firing.

3) Incomplete or partial evaporation of aluminum. This could mean that a filament is broken and not vaporizing the metal, or an electrical contact in the vacuum chamber is not functioning properly.

Excessive pull-down time can be the result of: 1) leaks which require the use of a leak detector; 2) foreign materials present in the vacuum chamber; 3) undercured base coats that are outgassing; 4) faulty pumps; 5) gages needing recalibration; or 6) excessive humidity.

Occasionally, an empty chamber should be pulled down to check for abnormal pull-down time.

Discoloration of the film could take the form of a blackening or darkening which would indicate a burning or outgassing. If the base coat requires a baked system, the oven might be in need of recalibration.

Discoloration may also be caused by fluctuation of power supply to the filaments. Or, the pressure in the vacuum chamber may not be sufficiently low.

Coating problems

Blush or fog: A haze or fog, referred to as humidity blush, is caused by the use of improper solvents. These solvents may, in highly humid conditions, condense moisture and cause blush. Suppliers can usually recommend substitute materials or additives when this condition arises.

When blemishes and/or a loss of adhesion are localized on a piece part, there is a possibility that this is caused by contamination with mold release. If the part is plastic and if the mold release is a zinc stearate, it can often be removed by the use of the thinner supplied with the coating material. If the mold release is a silicone, the problem usually shows up as craters, and special cleaners are needed.

Blackening or burning: This problem usually presents itself when parts are removed from the vacuum chamber. Aside from mechanical difficulties which may have taken place, it is best to investigate immediately whether or not the outgassing occurred because the base coat had not cured sufficiently. Where lacquers are used and have a prescribed air dry time plus prescribed force dry cycle, too short an air dry may allow slow solvents to be entrapped. When the parts are later metalized, the undercured base coat will then outgas and produce blackened areas.

Imperfections: Vacuum metalizing magnifies small imperfections and the problem of dust or lint is often one of the more difficult ones to solve. A small, clean spray room, supplied with filtered air, is ideal. It should be as simple as possible with smooth walls, ceilings, and floor to reduce the possible accumulation of dust. The spray room should never be used for storage, even for cartons of production parts. Cartons and corrugated cardboard are frequent offenders. Materials brought into the department should be as dust-free as possible.

Some firms replace the air exhausted at the spray booth and force filtered air into the room in sufficient volume to maintain a definite pressure at all times. A practical solution is a tight, clean room equipped with filters in the walls or ceilings to remove the dust from the air as it enters.

INTRICATE DECORATIVE work can be done on parts as small as this acrylic automobile medallion. Application of three separate colors and gold (by a combination of spray painting and metalizing) was performed on rear surface to give an attractive three-dimensional effect

PAINTING PLASTICS

By Lloyd E. Parks*

1. Design and Molding

Plastics parts must be molded relatively free of stresses to avoid unnecessary crazing or cracking in use. Stresses may be introduced when parts are machined, flexed, shocked by impact, or subjected to abrupt and uneven changes in temperature or the action of certain solvents. Crazing results in distinct surface cracks or minute frost-like internal cracks when stresses exceed the tensile strength of the plastics. When local stresses are present but are less than the tensile strength of the plastic, the part is under strain and may appear perfectly sound yet may crack or craze at a later time if additional stresses, sufficient to exceed the tensile strength, are introduced. Quality parts must be molded relatively strain-free and this is particularly important if they are to be decorated by painting (1).[1]

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*President, Parks & Co., 1413 Wachovia Bldg., Charlotte, N. C., and Vice president, Bee Chemical Co., 12933 S. Stony Island Ave., Chicago 33, Ill.

If parts are to be decorated on the second surface, assembly lugs, reinforcing ribs, metal inserts, knockout pins, and sprues must be located with care since they may show through the clear plastic and spoil the effect. If parts are to be spray painted in more than one color, edges and corners must be sufficiently sharp to insure close fitting of spray masks. Narrow deep grooves and small holes must be sprayed at a very small angle, which tends to fill the bottom of the groove or hole without coating the side. Paint tends to pull away from small raised angles, making them more difficult to spray than large angles or areas which have rounded surfaces.

If a part is to be silk screened, the area must be flat or at least smoothly curved. If letters are to be filled by the spray and wipe method, they must be sufficiently deep to avoid wiping the wet paint from the indentation.

If parts are to be decorated completely or in part by hot-stamping, the method of hot-stamping should be determined in advance and the part designed for the operation.

Annealing

Even with the best of design and molding techniques, many parts must be annealed to avoid rejects on the paint line. Some molders anneal all plastic parts; others anneal only those that cannot be molded sufficiently free of strain for decorating. In the case of the latter, the decision to anneal comes after all attempts to adjust paint solvents and molding cycles fail to produce parts satisfactory for decorating.

The most satisfactory method of annealing is to apply heat at a relatively low temperature for a long period of time. Polystyrene is commonly annealed at approximately 140° F. for 4 to 8 hr., depending on the type and size of the part. Acrylic parts may be annealed at 135 to 160° F. for varying lengths of time depending on the type of part and the type of acrylic plastic. Parts of either acrylic or polystyrene may be taken directly from the press and dipped into hot water for annealing. Seven to 10 min. at 140 to 180° F. should be sufficient for most parts. However, the precise temperature and time cycle must be worked out separately for each part.

There is a chance of warping parts in the annealing operation and in some cases it is necessary to clamp them in a jig to maintain shape.

When annealing in a water bath, it is common practice to use a small amount of detergent to promote wetting of the part and rapid draining as parts are removed from the bath. Such wetting agents may also serve to reduce static electricity on the part and thus reduce the amount of dust collected between annealing and decorating. Such wetting agents should be selected with extreme care, since they remain on the part and may adversely affect the degree of paint adhesion.

Cleaning the part

It is desirable that plastics parts be designed so they can be molded relatively strain-free without the use of mold lubricant. Mold release lubricants interfere with paint adhesion and must be removed. Moderate amounts of stearate lubricant may be removed with solvents which do not attack the plastic surface. Silicones are more difficult to remove with solvents. The Dow Chemical Co. (2) recommends a solution of 4 oz. of Oakite No. 24 in 1 gal. of water for removing silicone lubricant. A 20-min. immersion of the molded part in the solution at 145° F. is recommended, followed by a water rinse. This solution will also remove stearates and other contaminants.

Parts should also be dust-free for decorating. It is helpful to dip the parts in an antistatic solution immediately after molding to reduce the amount of dust contamination between molding and painting. Antistatic agents which do not adversely affect the paint adhesion must be chosen.

Some parts are wiped just before painting to remove dust and other contamination.

2. Selecting the Paint

Plastics differ in physical and chemical properties, and these differences affect the type of paint required. It is, therefore, important to select a paint specifically for the plastic to be decorated.

In the plastics industry the term "paint" is used broadly to cover both lacquers and enamels (3). Lacquers are particularly desirable for use on thermoplastic surfaces since the film hardens without baking. This eliminates the possibility of heat shrinkage and warpage of molded parts. Also, parts rejected because of blotches or errors in painting can usually be reclaimed quite easily by removing the paint with a combination of paint solvents inactive toward the plastic. Enamels harden by solvent evaporation and subsequent oxidation or polymerization or both. Enamels may be considered as thermosetting and are particularly useful for thermosetting plastics such as phenolic polyester, urea, and melamine where reasonably high baking temperatures can be tolerated without damage to the part.

Colors: Plastics parts are decorated to make them look better; in most cases the paint serves no other purpose. Accordingly, color is most important. To facilitate production color matching and color control, it is recommended that designers use a reasonable number of pigments, no more than three or four at the most, in arriving at colors. It is most important to work with single pigment colors in blending at the design stage. It is a mistake to blend three or four matched colors, each of which may contain three or four pigments, and expect an exact or even an approximate match in production.

Preparation for use: Paints are mixtures and in all cases it is necessary to stir well before using to assure uniformity. Unless careful study is given to selecting an alternate, the recommended thinner should always be used. Adhesion, gloss, humidity blush resistance, cratering, orange peel, etching, crazing, dry time, and stability of the paint system may depend on the thinner.

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[1] Numbers in parentheses link to Special references, p. 803.

Control: In setting up a decorating job it is important that paints be evaluated thoroughly and specified to meet the requirements of the application. Such points as grease resistance, humidity resistance, stain resistance, light resistance, heat resistance, abrasion resistance, gloss, adhesion, viscosity, and percent solids should be checked. Once the decorating job is under way, it is impractical to check all these points on each incoming batch of paint. Such control is unnecessary since it is improbable that basic errors in formulation will occur that cannot be detected by less extensive routine control.

However, each batch should be thoroughly mixed and checked for color. If special thinners or retarders are used to correct problems in production, the color should be watched to catch any irregularities that might arise from improper compounding.

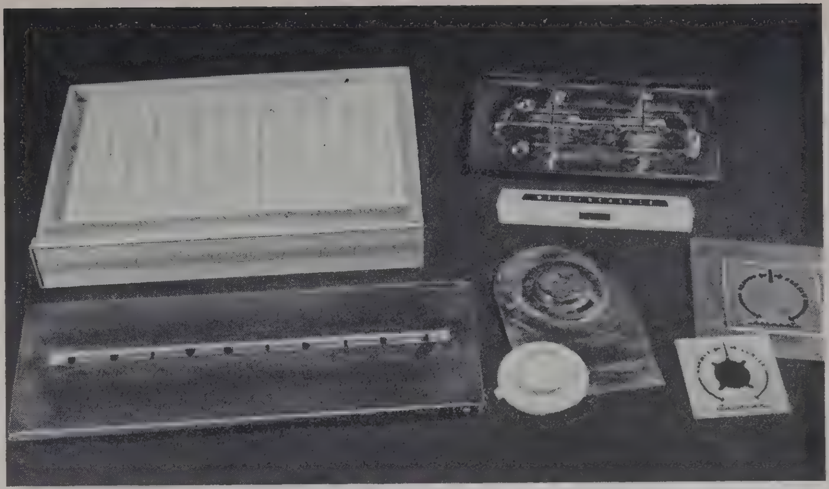
Production parts should be checked by visual inspection and a spot check should be made for adhesion. Many companies have accepted transparent Scotch tape #600 and masking tape #202 (Minnesota Mining and Manufacturing Co.) as the standard materials for the adhesion test.

3. Spray Painting Methods

Spray coating is widely used for decorating all types and sizes of plastics parts. The method is particularly adaptable for painting large areas and uneven surfaces and for the application of multiple colors by the use of spray masks. Spray coating is quite economical as a decorating method and productivity is high in well-equipped paint shops.

Suction feed guns and reasonably small suction cups are commonly used in spraying small areas and parts in short runs. Uniformity of the paint film depends on careful adjustment of paint viscosity, air pressure, and upon the gun opening.

Pressure feed tanks are used almost exclusively for spraying large areas or in long runs requiring a large volume of paint. The tank is connected directly to a conventional hand or automatic spray gun by a fluid hose and the paint is forced from the tank to the gun by air pressure. Since pressure feed tanks are stationary in operation, they should be equipped with air agitators to keep the paint well mixed. This is particularly important in the spraying of paints in which particles such as pearl essence and metallic powders have been suspended.



FOUR SPRAY PAINTED PLASTICS PARTS and the masks that were used for each. The mask in the top row is a "lip-type mask" that fits tightly over the piece being sprayed. Note the bridging of suspended details in masks of this type. No subsequent wiping is required after spraying. The other three masks are "block-types" that do require wiping to remove over-spray after painting. (Photo, Nosco Plastics)

Uniformity of spray application is particularly important in spraying metallic and pigmented metallic finishes. If one panel is sprayed extremely dry and another extremely wet, the colors may differ appreciably due to the difference in the degree of flooding of the powder. If sprayed dry, the film may be almost immobile when it hits the plastic, thus allowing very little flooding or orienting of the powder. On the other hand, if the film is extremely wet when sprayed, the powder may flood excessively, giving a quite different color.

For spray application, paint is usually thinned to a standard viscosity suitable for the particular job. It must be thinned sufficiently to spray, yet the resulting film must be viscous enough to hang on corners and edges when the paint hits the part. This is accomplished by use of a low-boiling solvent which evaporates between the spray nozzle and the plastics surface, allowing for an increase in viscosity in the paint before it hits the surface. Extra-high-boiling, high-boiling, and most of the intermediate-boiling solvents strike the plastic part with the paint as it is sprayed and control the properties of the wet paint film. Groups of solvents are classified in Table I, p. 802.

4. Screen Process Printing

The general subject of screen process printing has been covered in detail by Kosloff (6) and most of the general technology is useful in decorating plastics.

The process is used extensively for printing both flat and curved surfaces on a wide variety of molded parts. It is particularly adaptable for multi-color decorating by successive screening operations with a series of different screens. It is more economical than spraying for decorating elaborate designs.

The basic equipment used in screen process printing is the screen, commonly called the "silk screen," regardless of the fabric used in its construction, and the squeegee which is used to force paint through the design in the screen to the part which is being printed.

The screen consists of a taut woven fabric securely attached to a rectangular wooden framework and carefully masked with a stencil in a manner that will allow

TABLE 1: Classification of paint solvents

Low-boilers	*Intermediate-boilers*	*High-boilers*	*Extra-high-boilers*
Methanol	Isopropyl alcohol	Amyl acetate	Cellosolve acetate
Ethyl acetate	Sec-butyl acetate	Butyl acetate	Butyl Cellosolve
Isopropyl acetate	Methyl Cellosolve	Butanol	Butyl lactate
Acetone	Methyl isobutyl ketone	Diisobutyl ketone	Methyl carbitol
Methyl ethyl ketone	Toluene	Xylene	SC-150
Hexane	VM & P naphtha	SC-100	
Heptane		Methyl Cellosolve acetate	

paint to be pressed through the fabric only at areas where the stencil is open.

Woven silk, nylon, copper, stainless steel, and many other materials are used in making blank screens. Nylon has replaced silk and is perhaps the material most commonly used in screens for printing molded plastics parts.

The mesh of fabrics used in screens for such work usually varies from 125 to 150. However, screens are commonly classified by the number classification of the fabric used. By this system, numbers 12, 14, and 16 screens are most common. As the number increases, the mesh of the screen becomes finer, with a resultant thinner film of paint on the printed part. Thin films give better detail but may result in poor hiding.

Design printing: For design printing, a stencil must be added to the blank screen. This may be accomplished by several methods. However, simple water-adhering film and photographic stencils are generally used in screens for printing molded parts. Sheet stock designed for water-adhering film stencils is available from The Craftint Mfg. Co., Cleveland, Ohio, and other suppliers. It consists of a water-soluble film backed with a thin sheet of plastics or specially prepared paper.

Photographic screens are used extensively and are particularly desirable for intricate designs. Essentially the process is quite similar to printing a snapshot from a negative. The commonly used positive film is called "carbon tissue" and consists of pigmented gelatin emulsion, or a similar colloidal film supported by a backing which can be a flexible plastic.

Applying the paint: The squeegee is a tool used to force paint through the design area of a screen in the painting operation. It is made of solvent-resistant material and is equipped with a handle for hand operation or with a holding device which can be designed to be used in machine operation.

The squeegees are usually about 0.25 to 0.50 in. thick and for good printing the working corners must be kept sharp by sanding the bottom or working end. A small vertical jig with a slot about as wide as the thickness of the squeegee and with fine sandpaper in the bottom is useful for this operation. Squeegees must be kept clean and it is desirable to have a different one for each color. For a particular operation, the squeegee should be slightly shorter than the inside of the screen frame to allow ease of operation, but it should always be long enough to cover the entire design area in just a single stroke.

The flat plastic part is placed under the screen, in register, and the screen adjusted for a clearance of approximately ⅛ inch. This clearance serves the purpose of allowing a line contact as the squeegee is pulled across the screen under pressure in the printing operation. The operator takes the squeegee firmly, preferably in both hands, and dips it into the paint, leaving a small amount in front of the squeegee along its entire length. It is then pulled forward over the design with an even stroke and enough pressure to make a line contact with the plastic part as it moves. The squeegee is returned to the back, the screen lifted, and the printed part is then removed. Good screening paints or inks are available for use on practically every type of plastics including treated polyethylene. Paint must be selected, however, for the particular job and for the plastic to be decorated. Generally speaking, lacquers are more desirable than enamels for printing thermoplastics, as was the case with spray finishing. Enamels are generally more desirable than lacquers for thermosets.

Some molded plastics parts are screened by automatic or semiautomatic setups when volume production is required. This is particularly true of parts such as bottles and containers, which often have curved surfaces.

5. Dip Coating

Dip coating is economical and is used widely in decorating novelties, toys, and other objects that require only one color and are so designed that excess paint will drain off without being trapped. From the standpoint of appearance, dipping gives a very uniform paint film, but it should be noted that rapid production prohibits application of uniform paint thickness. If parts are withdrawn from the dip tank at a rate faster than they drain, the film will be thicker at the bottom and excess paint will remain on the bottom edge as a line or tear. Such tears may be removed by spinning the part or by hand wiping at some extra cost. For large-scale production it may be desirable to remove parts slowly for better drainage.

When pigmented paints are used, some method of agitation must be arranged to assure uniformity of the mixture. This may be accomplished by pumping material from the bottom to a point just beneath the top surface of the paint mixture or it may be done with a mechanical agitator as long as the formation of air bubbles is avoided.

The solvent system of dip finishing must be adjusted to allow good flow-out and drain without sagging. The gel time and film thickness may be controlled somewhat by use of low-boiling solvents which serve to reduce the viscosity of the paint in the dip tank but evaporate rather rapidly on application. Paint in dip tanks may lose solvent with a resultant increase in viscosity. This can be corrected by the addition of the proper make-up thinner.

Parts may be dipped singly, by hand, or by jigs that hold several parts. If they are withdrawn more rapidly than they drain, a drain board must be provided to catch drippings. Chain conveyor installations are used for large-scale production.

6. Roller Coating

Small raised areas such as letters, figures, and designs may be decorated with paint by roller coating. This method is particularly useful in many cases as an alternate for hot-stamping. It has an advantage over spray coating for such operations in that simple loose-fitting block masks may be used or the part may be rolled without a mask. For best results the raised areas should have smooth flat surfaces and all points to be roller coated in one operation should be in one plane or at least be in a cylindrical arc. The edges and corners should be sharp for good detail.

The paint must have good adhesion since many raised areas are especially subject to wear. The solvent system must be balanced to allow flow-out but the film must gel or become immobile before it has a chance to run off the raised area.

Hand rolls are commonly used for short runs and for areas that cannot be rolled by machine. A small amount of paint is placed on a flat surface such as glass and the roll is coated by rolling it back and forth in the paint. The coated roller is then moved back and forth over the raised area to transfer the paint. Automatic roller coating machines are available for handling large runs but must be adapted to the particular job.

7. Fill-in Marking

Depressed letters, figures, and designs on either the first or second surface of plastics may be easily and rapidly filled by the spray-and-wipe method. A single depression or a series of depressions may be filled by spray coating the general area without a mask, or spray coating a restricted area around the depressions with a loose-fitting block mask. The job is completed by buffing or wiping the excess paint from the area surrounding the depressions. The wiping operation may be performed by hand or it can be accomplished with an automatic machine.

In the automatic setup, parts are secured in a cup-like jig and raised by an air lift for wiping. The shaft holding the parts rotates, thus wiping the part on the cloth as pressure is exerted by the opposing cushioned jig.

Enamels must be removed before they cure and it is desirable that lacquers be wiped before they are completely dry. Since regular lacquers and enamels are sticky by nature, it is always necessary to remove the last traces with a solvent which does not attack the plastic. Spray-and-wipe finishes must be formulated to avoid etching the plastic. In the case of second surface decorating, etch will show up against the color subsequently applied over the area; it will also mar appearance in the case of first surface decorating, particularly if the area surrounding the fill-in is not painted.

"Dry-wipe" formulations are generally more desirable than regular lacquers and enamels for spray-and-wipe fill-in. These highly pigmented materials are easy to use and may be wiped or buffed without a solvent over a period of time ranging from about 20 min. to several hours after spraying. Generally these materials have poor gloss as a result of the very high pigmentation and it takes them several days to reach maximum hardness. They can be packed or further decorated almost immediately after the buffing operation; if parts are to be decorated by the spray-and-wipe method, the depressions must be rather deep and narrow to avoid complete removal of the paint in the wiping or buffing operations that may follow.

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EQUIPMENT FOR PAINTING PLASTICS

By C. V. Scantlebury*

The term "decoration" is here used to describe the selective application of paint to certain areas. It is not meant to include overall spraying of the plastic part or dipping.

Spray painting through masks

Hand spraying: A hand-operated spray gun, a mask, and a clamping fixture are basic equipment to produce quality work manually. Stock fixtures are available which can be adjusted to accept various sized masks. Special fixtures can be made to take parts which, because of their size or shape, are not readily painted in a standard fixture.

Automatic spray painting machines, fed either manually or by a hopper, are ideal for extra-large production runs; labor is, of course, kept to a bare minimum. The complexities of such machines, however, limit their use to painting parts which have a volume or value sufficient to justify the required capital outlays.

Semi-automatic machines are, because of their versatility and moderate cost, used extensively for painting parts, whether for short or long production runs. Most of these machines can be changed over to a new job in 30 min. or less, and are capable of handling a variety of sizes and shapes with a simple tooling

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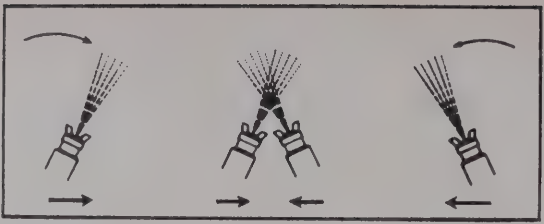
*Sales Mgr., Finish Engineering Co., Inc., 1115 Cherry St., Erie, Pa.

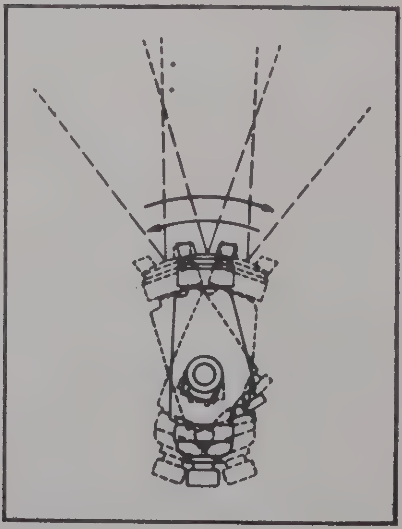


RECIPROCATING GUN MACHINES are usually necessary for painting parts over 12 in. long. See text for description of their operation

change. Using these machines requires an operator to load the part, actuate a starting device, and then unload the painted part. Production rates of 400 to 1000 parts per hr. are being achieved. The various types of semi-automatic painting machines can be identified by their spray gun motions which are: 1) reciprocating; 2) oscillating; 3) swinging; and 4) fixed gun-rotating parts.

1) Reciprocating gun machines are usually necessary for painting parts over 12 in. long. The more efficient machines of this type carry the spray guns on an overhead carriage and paint the part with one over-and-back motion. To paint under bridging wires on the mask and to cover vertical walls, the spray guns are tilted at the end of each stroke so that they spray ahead of the carriage. The carriage can be powered electrically, hydraulically, or pneumatically, air being best for short strokes and an electric motor best for smooth travel on long strokes.

OSCILLATING GUN MACHINES impart wrist action to spray guns and are best for painting of flat and concave surfaces on small parts



2) Oscillating gun machines impart a wrist action to the spray guns and are best for painting flat and concave surfaces on small parts. An oscillating spray gun gives satisfactory coverage when the bridging on the mask is simple; when there is considerable bridging, however, a different type of gun motion should be used to avoid bridge shadows.

3) A swinging gun machine has the particular advantage of painting around bridge work most efficiently. It is an excellent choice for painting both convex and concave surfaces, the path of the paint pattern being adjusted by varying the arc through which the gun swings.

4) Fixed gun painting machines, of course, require the part to be moved to achieve more than spot coverage. Rotating the part while painting will give excellent coverage on all round, spherical, cubical, and flat shapes. This type machine is the most versatile of all painting machines, since more shapes can be accomodated and more effects produced than with any other machine. For example, two or three colors can be sprayed on a part in one operation. As many as five colors have, in a few instances, been sprayed at the same time. Of course, a distinct separation of colors must exist for multi-color spraying to be possible. In addition, the separation must be on a circular plane. Ease of set-up is another advantage of this machine since the guns are fixed and easily accessible. Dissimilar coatings can be sprayed in succession on the same area.

Special painting machines can be designed when none of the standard units will do the job efficiently, e.g., when painting odd shapes or special effects. To handle a large-production run, dial-indexing machines are frequently used. Chain-on-edge machines are often used to apply protective coatings with a mask, as well as for painting the entire outside surface of a part.

Mask washers

Mask washers are essential to production painting and are used with most painting machines. When clogged with paint, the mask is placed in a washer and cleaned while the painting operation continues with the use of another mask.

There are several good types of mask washers. The most popular of these brings a solvent into contact with the paint-clogged mask by agitation, pumping, spraying through nozzles, or whirling in a spinning barrel. The most recent development in mask washing techniques sweeps the entire mask back and forth through the washing solvent. This reaches all the surfaces equally and has proven to be the fastest method yet devised.

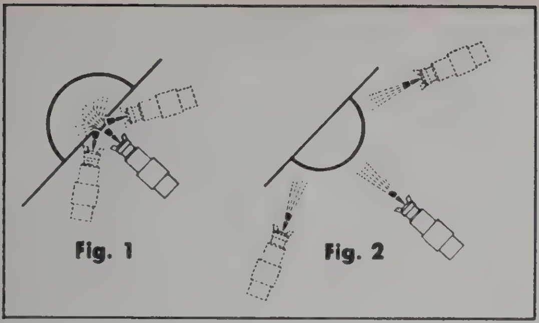
Fill-and-wipe painting

This technique is used on numerous plastics parts such as automotive speedometer and indicator dials, appliance adjusting knobs, and controls. These parts are molded with a depressed design of fine lettering, arrows, scales, and indicating lines, which are often too small to be masked efficiently. Paint can be applied to parts of this nature by spraying in one of the four standard methods or by automatic contact filling.

The surplus paint is then wiped off the areas which are to be clean, the wiping being done on a semi-automatic paint wiper which presses the painted part against a towel with controlled pressure and movement. Preset cycles and movement are quickly adjusted to a wide variety of parts. For high production runs, the painting and wiping can be combined in one machine especially designed to provide both the painting method and wiping motion best suited to the part's shape.

Roller coating

Roller coating is often used for coating raised designs or letters. In many cases, spray painting such designs through masks is



SWINGING GUN MACHINE can paint around bridge work most efficiently. It can be used for painting both concave (Fig. 1) and convex (Fig. 2) surfaces

not practical due to delicate mask construction and necessity for extreme part accuracy.

While hand rollers with block cut masks are used for short runs, roller coating machines give very high production rates and close quality control on large runs. Raised letters on dials are coated with a circular motion; even slightly conical shapes have been done both inside and outside. Stripes may be applied to uninterrupted surfaces even though raised ribs are not molded into the part.

Screen process printing

Screening machines are used to apply decoration by what is often called the "silk screen" process, although today other materials, such as synthetic or metal fibers, e.g. nylon, or stainless steel, are used for the screens. For a short screening run, the cheapest screen material is likely to be most economical. For the longest runs, a stainless steel screen gives lowest unit cost. Most screening machines are used for decorating flat surfaces, but cylindrical surfaces may be decorated. Some types of dials can be screened with a circular motion of the squeegee.

A great improvement in screening efficiency has been realized through the development of air fixtures which bring the part accurately into position and hold it there during screening. Another timesaver for setting up a job is the part holder mount with knob-controlled micrometer adjustment in three directions for accurate location of screen to part, thereby aiding in registration.

The companies specializing in the manufacture of decorating tools and machines have advisory services available to the trade. These include recommendations on part design for most efficient decorating as well as advice on equipment and production procedures.

SPRAY MASKS

By Hamilton E. MacArthur*

In spray painting for decorating plastics, the areas not to be painted are covered by a durable form-fitting metal mask. Masks made by electroforming are preferred because they conform to the contour of the article, and are superior to shaped sheet metal, stampings, or metal castings; castings of conventional metals, made from the plastics article as a pattern, do not fit well because of shrinkage; castings of low-melting alloys fit satisfactorily, but are weak and not durable.

There are four basic types of electroformed masks:

The *lip-type mask* (see Fig. 1, right) is used for painting a depressed name or design. In this mask, a lip of metal extends down the vertical side wall of the depressed design, all the way or only part way down the side wall (depending on the result desired). This lip must be thin, yet strong. The centers of letters and numbers such as O, A, 6, or 8 must be securely held in place by bridges. The fit and the lip of the mask ensure a clean sharp paint line. Draft angle of depressed design should be at least 5 degrees.

The *cap type* (Fig. 2, right) is the reverse of the lip. It is used where the embossed name or design is to be kept clean while painting the background. The lip of metal must cover the vertical side walls all the way to the bottom, so as to completely protect the embossing.

The *plug mask* (see Fig. 3, p. 806) is used for protecting a depressed design while painting the background. Its principal use is with transparent articles such as automobile horn buttons and doors of refrigerator evaporators and for applications where vacuum metalizing is required. Here again, the positive fitting essential to prevent fogging on vertical side walls and bottoms of such designs is accomplished by electroforming directly into the design. The plugs are cut out, and finished with the proper radii and draft angles to facilitate painting. They are then suspended by fine wires, usually attached to a frame so as to provide a unit which can

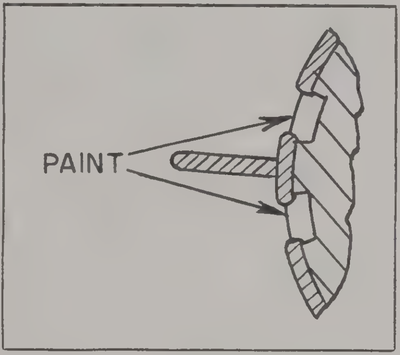
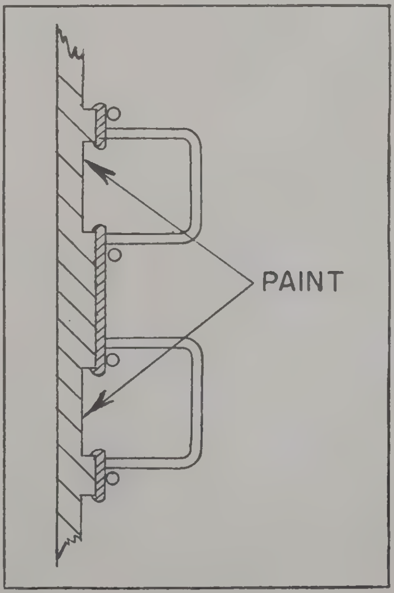


FIG. 1 (ABOVE): Lip mask for spray-painting sunken designs; **FIG. 2 (BELOW):** Cap mask for protecting a raised design



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*President, Conforming Matrix Corp., Toledo Factories Bldg., Toledo 2, Ohio.

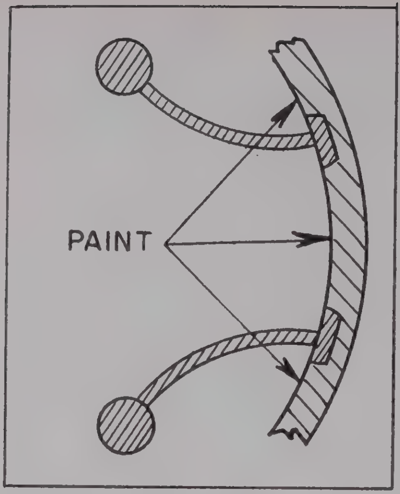
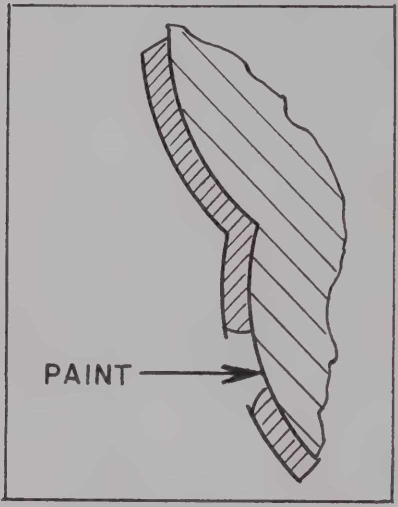


FIG. 3 (ABOVE): Plug mask for protecting depressed designs; **FIG. 4 (BELOW):** Block cut-out for fill-in painting



be easily handled during various production operations.

In designing molds, the engineer must remember that the draft angles of the depressed design should be kept to a minimum, preferably not more than 5 or 7 degrees.

Spray painting through a *block cut-out mask* (see Fig. 4, left) is a variant of fill-in painting. The method is used primarily in filling depressed letters and calibration marks on such articles as knobs for stoves and radios, since spray painting is not satisfactory for articles with fine calibrations. For masking small letters and pips, the openings in the mask would be so small that they would immediately become filled with paint. Instead, a cutout is made to enclose each character or group of characters, to confine the paint to the immediate area. Then, the excess on the surface is removed by wiping or buffing, leaving the depressed characters filled with paint. Articles made in multiple-cavity molds are not fully uniform in dimensions, but the block cut-out mask can usually be designed to accommodate all of them.

The mold engineer should design the mold with thought to the problems of masking. Slight changes in the demarcation of colors which will not essentially change the design of the article may serve to definitely facilitate masking.

Other factors in mold design and molding have more fundamental influence on the ease of decorating the molded article. The position of knockout pins, radii, flat spots, and contours can make the decorating job very difficult and costly or easy and inexpensive. If dimensional differences between cavities cause trouble, articles with different cavity numbers can be handled separately. Mold lubricants should be used very sparingly unless provision is made for removing them from the molded articles.

HOT-STAMPING

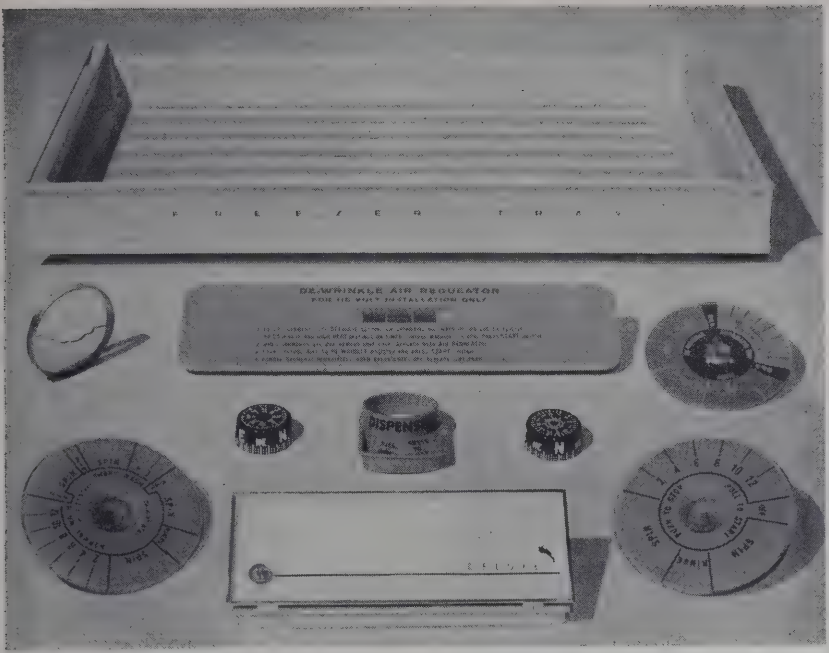
The hot-stamping process is based on the use of stamping equipment in conjunction with a pigment colored leaf of foil which is created by coating pigmented paints on a film backing or carrier. The pigments are held in a dry, suspended state until, under heat and pressure, they become mastic. At the same time, the heat softens the surface of the plastic to effect a homogeneous bond between color and plastic. The entire operation takes place in special hot stamping equipment in which the plastics parts are fixed in a jig located under the head of the press. The roll leaf is then fed under the head and is brought into pressure contact with the plastic by an electrically heated die in the press head. Contact is maintained for a sufficient time to allow the pigment to transfer to the plastic.

The techniques to be used in hot stamping depend, of course, to a large extent on the type of plastic being decorated. The heat ranges used, for example, run from 175° F. for cold operating leaf up to 500° F. for silicone rubber die stamping and phenolic marking. Generally speaking, the thermoplastics will take the lower heat range and the thermosets will take the higher range.

As far as pressure is concerned, vinyl and polyethylene, the softer plastics, require little pressure, whereas phenolics and the other hard plastics will take extremely high pressures. The same "rule-of-thumb" applies to determining the proper dwell time. Vinyl and polyethylene require extremely short dwell or "kiss" impressions; the harder plastics, such as polystyrene and phenolic, need more time to give the die a chance to get below the surface of the plastic.

Basically, there are three types of stamping equipment: hand-operated, motor driven, and air-operated. Until recently, the production rate for these machines hovered around 2000 pieces an hour. Now, however, automatic equipment, generally based on the use of a rotary indexing turntable, have performed the process at a rate as high as 4500 to 5000 pieces an hour. Techniques of this type, of course, are based on the use of hopper feeding, conveyor feeding, or rotary indexed table feeding to replace the manual feeding lines. The determining factor in production speed, however, is still the rate of dwell required for the particular type of plastic being decorated.

Another important recent development in the field is the appearance of silicone rubber dies which can be adapted to depositing leaf on molded-in raised sections. If the plastic piece is transparent, the lettering can be molded-in in reverse and hot stamped with the rubber dies on the back to achieve interesting three-dimensional effects. If the part is opaque, the lettering can be molded-in on the front and easily topped with leaf to give a two-color effect. When using the silicone rubber dies (the rubber is about ⅛ in. thick and is bonded



TYPICAL EXAMPLES of the art of hot-stamping. The freezer tray (top row) has raised letters which are hot-stamped with a flat die. The round items (left and right) are decorated by a rotary hot-stamping operation. The dials (center) combine both hot-stamping for lettering and spray painting for background color. (Photo, Nosco Plastics)

to a steel or brass plate, also about ⅛ in. thick), it should be kept in mind that the heat conductance of the material is less than with straight metal and that higher heats are therefore needed. To obtain a temperature of about 275° on the face of the die, the head of the machine must be heated to about 425°—approximately 150 degrees higher.

Considerable development work has also been going on in perfecting the roll leaf material. Leaf manufacturers, for one thing, have diversified their lines so they can offer a specific leaf material for each specific plastic. Research has also gone into improving the carrier material. For many years, acetate and cellophane were the two most used materials; today, several manufacturers are using a Mylar polyester film backing. Although it is more expensive, it can be used in thinner gages than the other two, it is much tougher, and it makes possible more sharply defined detail.

Other developments: metallic leafs are now available to permit spot decoration (simulating metalization) in molded items; leaf in transparent colors can be stamped on the underside of a clear piece and metallized from the rear to give interesting color effects; and leaf in daylight fluorescent colors is now also available for added decorative appeal.

LABELS AND DECALCOMANIA*

Although not new to the plastics industry, there has been a recent spurt in activity in these decorating media that indicates their growing importance. The reasons behind this spurt appear to be threefold.

1) Excitement aroused by the introduction of the Therimage transfer labeling process by Dennison Mfg. Co., Framingham, Mass. Machines have already been developed to use the technique to decorate polyethylene bottles in up to 4 colors at speeds ranging from 50 to 100 units per minute. The polyethylene bottles can be decorated on two sides with one feeding or by setting up two machines in tandem. Round bottles can also be decorated the circumference of the bottle, allowing space for mold seams, with one feeding.

Cost savings with the process are claimed to be high. According to Dennison, decorating bottles by silk screening cost about $7 per pass for a thousand bottles. At this rate, a 4-color job on the face and two colors on the reverse side of a bottle would cost about $40 per thousand to decorate. By transfer labeling, the same decoration can be performed at the rate of approximately $10 per thousand pieces.

2) The recent appearance of high-speed machines for applying labels. New Jersey Machine Corp., for example, makes available two machines for applying labels to plastics items. Both machines use a suction label handling system. One of the units passes the label over a glue roll on the way to the item to be handled; the other heats the label as it is being delivered to the object so that the heat activates a precoating of thermoplastic surface on the back side of the label. The labels can be applied at speeds of about 60 per min. and have already been adopted by several manufacturers for decorating plastics toys and novelties.

3) New types of labels based on new materials. W. H. Brady Co., Milwaukee, Wis., for example, offers a label printed on Mylar polyester film that has outstanding abrasion resistance, weatherability, and can take temperature ranges from —60 to 300° F. The Park Nameplate Co., Inc., Flushing, N. Y., offers colored anodized aluminum plates for decorating a variety of plastic products. Both labels are backed with a pressure-sensitive adhesive. The Meyercord Co., Chicago, Ill., supplies a series of pressure-sensitive labels to be applied as a decoration to a line of reinforced plastics model automobiles. Tompkins' Label Service, Philadelphia, Pa., reports two further case studies: 1) A label simulating stained glass windows used by a toy manufacturer on a model church building kit molded of styrene; and 2) silver foil labels applied to the window area of plastic model boats. By reflecting light, the silver foil gives the appearance of a glass window.

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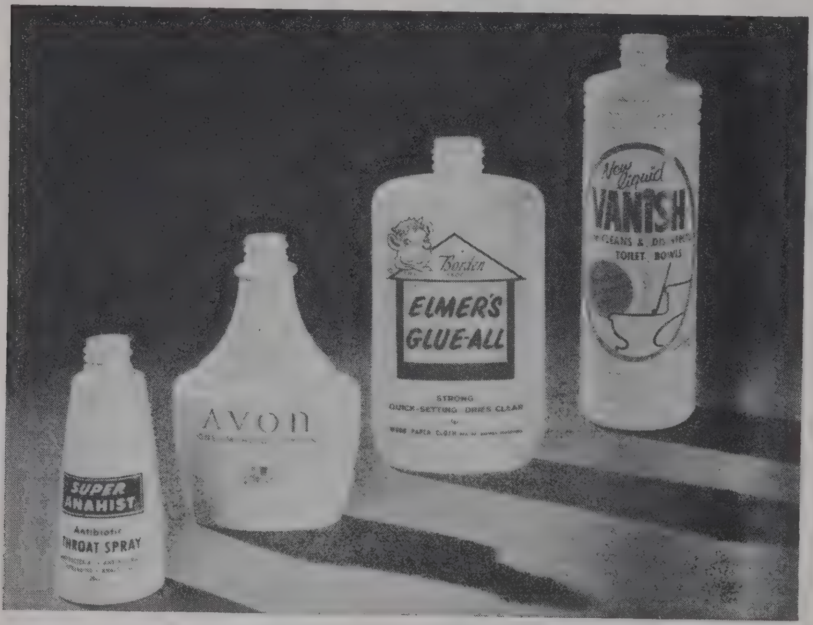
*Adapted from "Decorating Molded Products," Modern Plastics, April 1959, 36, p. 91.

MISCELLANEOUS DECORATION*

Advances in the technique of molded-in foil decorations have been aimed at applying the technique to parts of more complex contour and design than simple, shallow dinnerware. Various novelties and cosmetics packages look as if they will be first on the list.

Although vacuum metalizing still remains the most popular technique for applying a metal finish to plastics, a number of other methods are also currently in use. Anchor Plastics Co., Long Island City, N. Y., for one, has developed a technique for extruding a metal foil inside of a clear butyrate strip. The finished effect is that of a metal trim.



FOUR METHODS OF DECORATING polyethylene bottles (left to right): silk screening; hot stamping; labeling; and offset printing. Table below compares three of the processes; labelling is covered on p. 807

Table I: Comparison of processes for printing polyethylene bottles[1]

Characteristics	*Silk Screen*	*Hot Stamping*	*Offset*
Permanence	Good	Good	Good
Colors	All	All	All
Metallic effects	Fair	Good	None
Multicolor			
Appearance	Good	Good	Fair
Practicality	Poor	Fair	Good
Require separate pass for each color?	Yes	Yes[2]	No
Registration	Fair	Fair	Good
Production speeds	Good	Good Plus	Fair
Size limitations	None	None	None
Holding-jig requirements	Simple to difficult	Difficult	Simple to difficult
Laydown of ink	Heavy	Medium	Light
Appearance			
Small type	Fair	Fair	Good
Heavy designs	Good	Good	Fair

[1] This chart is intended only to supply a rough definition of some commercial methods of integrally marking polyethylene bottles. Certain conditions will alter this rough evaluation. In any case, your decorator is your best guide.

[2] Mechanical set-ups involving multiple stamping heads in series have converted hot-stamping multicolor work into practically an automatic operation, especially on long runs.

This chart prepared by A. N. Skeels, Art Decorating Co., North Bergen, N. J., and reprinted from Modern Packaging Encyclopedia Issue.

In another variation, Planet Plating Co., Inc., Brooklyn, N. Y., makes use of a barrel plating technique in which a thin film of silver is deposited on the surface of the plastic to make it electrically conductive. Between 2 and 5 mils of copper are then plated on top of the silver and the plastic is polished in the burnishing barrels by a mixture of steel shot and lubricating soap. Barrel plating is recommended for smaller parts—generally up to 2½ in.—and has thus far been used to apply a rich finish to novelties, buttons, toys, and advertising specialties.

From G.M.C. Process Corp., Bel-Ve-Dere Div., New York, N. Y., has come a technique for applying a variety of openwork or "filgree" patterns to plastics by electrolytically laying down a layer of sterling silver. This technique has been refined to the point where personalized names can be worked into the lattice designs.

A number of methods are also available for molding or extruding parts with more than one color. Borden Hively Co., Columbus, Ohio, and Thermoplastic Processes, Inc., Stirling, N. J., are among those who can extrude shapes with stripes in contrasting colors. J. P. Gits Molding Corp., Chicago, Ill., as another example, uses a double shot molding technique.

Armstrong Cork Co., Lancaster, Pa., has developed a new technique for molding debossed designs into the sides of compression molded caps. Designs that can be handled in this way include names, trademarks, floral designs, etc.—in contrast to previous techniques which limited decoration on the skirts of plastics caps to a vertical direction.

Plastomatic Corp., Malvern, Pa., uses an elaborate three-dimensional design in which molded styrene figures in contrasting colors are cemented to the face of styrene housewares in much the same way as a conventional applique would be used.

And several molders of expandable polystyrene have put unusual effects to work on their products. La Della Plastics, Inc., Fox Lake, Wis., flocks its expandable styrene foam toy banks to give the appearance of a "fuzzy" teddy bear; Frank Plastics Corp., Detroit, Mich., adheres a sheet of embossed, printed vinyl to its expandable styrene ice buckets; and Polly Plastics, Inc., Cleveland, Ohio, uses black applique overlays on its expandable styrene planters.

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*Adapted from "Decorating Molded Products," Modern Plastics, April 1959, 36, p. 91.

Colorite Industrial Dyers, New York, N. Y., has developed methods for dyeing or tinting a wide variety of thermoplastic and thermoset parts. Rexton Finishes, Inc., Irvington, N. J., has an epoxy color finish for phenolic that can be sprayed on.

DECORATING FILM AND SHEETING

By Mark W. Neitlich*

While plastics film and sheeting possess many basic properties considered desirable by potential users, the enlargement and creation of consumer markets for plastics film and sheeting have been made possible largely through advances in the arts of decorating these products.

The decorating methods most widely used today are printing and embossing. Interesting specialty products are also being produced by laminating and by flocking.

The processes used to print plastics have been, basically, of the same types used by other industries. Their successful adaptation to plastics, however, has required continual change to meet the wide variety of problems which are introduced by new plastics materials. In most cases, these problems have been overcome.

Gravure printing

The gravure process has been the most widely used printing method for decorating plastics film and sheeting. Well-known in the industry, gravure printing involves the deposition of ink from depressions of a specific depth, pattern, and spacing, which have been either mechanically or chemically engraved in a cylinder. The cylinder is partially immersed in the ink fountain, thus allowing the depressions to be filled with ink. The excess is wiped out of the depressions and off the unengraved areas of the cylinder by a resilient metal blade, referred to as the "doctor blade." Cylinders are generally chrome-plated to protect the engravings, as long as possible, against the continued abrasion of the doctor blade. Since the unengraved areas must be wiped completely clean to avoid smudging unprinted areas of the plastics, scrupulous care must be taken to keep the doctor blade free from scratches and in smooth contact with the cylinder. The selection of inks must be made with equal care, since inks which are too highly pigmented or contain abrasive fillers tend to lower cylinder life markedly.

Less serious from the point of view of possible cylinder damage, but nevertheless harmful to printing quality, is a flocculated state of ink pigment dispersion. This condition is generally due to wettability of pigment in the vehicle portion, and can frequently be alleviated by addition of a reducing clear of high resin content.

The gravure process is characterized by finely detailed prints and high rates of production. Gravure presses, properly equipped with forced drying facilities between cylinders, can print as many colors as there are printing stations. One of the most highly desirable aspects of gravure printing is process work. In process printing, transparent inks in the three primary colors are printed over one another using cylinders engraved by means of photographic color separation. The process method couples the fine detail possible in gravure printing with the full gamut of color variations available from combinations of primary colors. The primary disadvantage of the gravure process is the comparatively high cost of preparing printing cylinders.

Gravure cylinders are used for applying both pigmented coatings and clear or tinted top coats to plastics, particularly in the manufacture of vinyl upholstery. The gravure method is also used in reverse printing, in which case the pattern is printed, in reverse, on the back surface of a clear film, which can then be laminated to thicker plastics sheets.

Inks used in the gravure process dry, usually, by evaporation and must be adjusted to fit the printing speed of the equipment, the diameter and depth of etch of the specific cylinder, and the plastic being printed. Drying temperatures must not be so high as to cause distortion of the plastic nor so low as to inhibit complete drying of the ink (especially in multicolor printing).

Flexographic printing

Flexographic printing is most commonly used in producing printed packaging films. It has had little application, until recently, as a method of decorating plastics film and sheeting. Decorators of plastics, particularly light-gage polyethylene, have noted the success of package printers in handling this material at extremely high speeds. In addition, the wide use of polyethylene for inexpensive throw-away items, such as draperies and tablecloths, has caused a swing toward the flexographic process because of its inherently low plate cost and its adaptability to numerous style changes. Although the fineness of detail possible in gravure printing is not obtainable in flexographic printing, this disadvantage is nullified in the case of light-gage decorated polyethylene because of the fact that almost all the materials sold are heavily embossed.

Recent advances in the formulation of flexographic inks for vinyl film have made this a practical method for the production of decorative films as wide as 72 inches. The biggest problem was the high plasticizer content of most vinyl films, with consequent

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*Technical representative, Claremont Pigment Dispersion Corp., 30 Powerhouse Rd., Roslyn Heights, N. Y.

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References were prepared by the editors.

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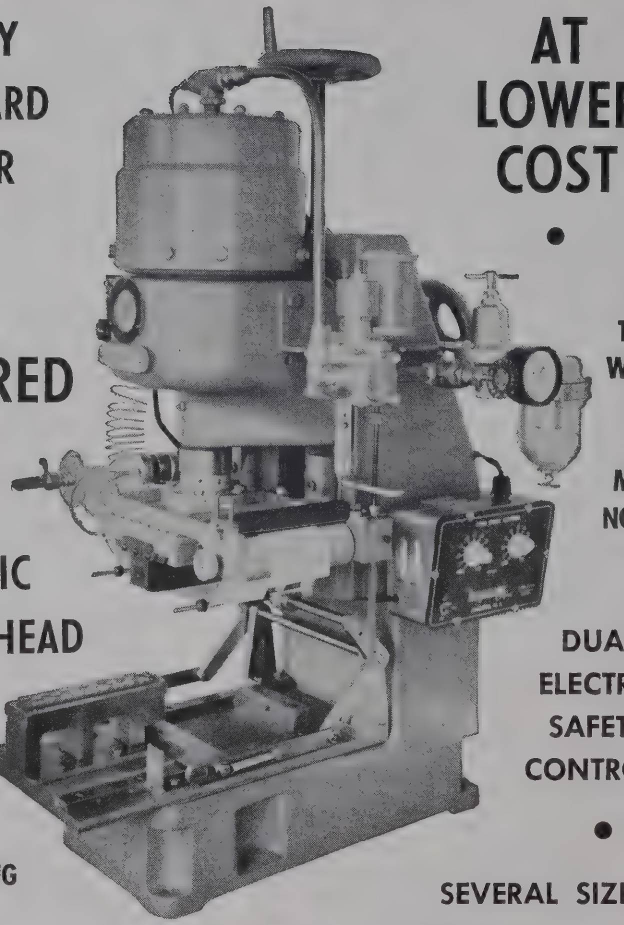

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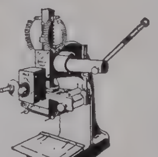

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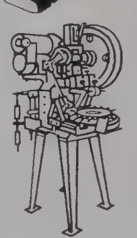

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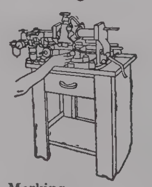

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plasticizer migration tendencies. Since a successful flexographic ink must be of low viscosity and, generally, fairly high resin content, it follows that the low-molecular-weight polymers best adapted to this requirement would most easily suffer tackiness due to plasticizer migration. Further, the resins which adhere to polyvinyl chloride film generally are dissolved only by ketones, aromatics, or other strong solvents which are also very active in swelling the rubber plates and cylinders used in printing. By selection of suitable solvents and resins, these difficulties have been largely overcome and flexographic printing of high quality is now possible on clean, not excessively lubricated, PVC film.

The plates used in flexographic printing are made of natural or synthetic rubber and have raised patterns. A rubber roll, partially immersed in the ink fountain, transfers ink to a fine screen-lined steel roller which, in turn, deposits a thin layer of ink on the printing plate which has been mounted on the plate roller by means of an adhesive. Inks, of course, must be rapid-drying. The potentially high printing speed of the flexographic process can be achieved only through the impingement of rapidly circulating hot air on the printed plastics after each color is printed. Until recently, the make-up of printing rolls and plates limited flexographic inks to the alcohol type. Recent developments, however, have made available solvent-resistant rubbers that permit printers to use universal inks based on stronger solvents.

Valley printing

Valley printing, also known as inlay printing, has only recently begun to enjoy wide use as a plastics decorating method. By adding a suitable auxiliary ink-furnishing unit to a conventional embossing machine, ink is applied to the high points of the embossing roll and is, subsequently, deposited in what become the valleys of the embossed plastic. The process opens a completely new area in plastics decorating by combining the effects of dimension with color. The ink-furnishing equipment consists, usually, of a combination of rubber rolls, or steel and rubber rolls. In either case, a rubber roll is used to deposit the ink on the embossing roll.

Since the plastic is preheated prior to printing, it was felt, at one time, that only water-based inks would be satisfactory for valley printing. Several years of trouble-free experience with specially formulated solvent-based inks have served to place the danger of fire in its proper perspective. The solvents used in these inks, however, must not attack the rubber rolls. Solvent-based inks have been used successfully to print a large volume of vinyl and polyethylene film and sheeting.

Each new valley-printed design requires the preparation of a different embossing roll. Valley printing can, therefore, be economical only where the roll is used to produce a relatively large volume of printed film or sheeting. Many currently operated embossing units can be equipped to valley print. Most, but not all, embossing rolls are suitable for valley printing.

Silk screen printing

Silk screen printing ranges in complexity from simple hand methods to semi-automatic operations on all types of plastics. This printing method, in its basic form, involves laying a pattern of an insoluble material, in outline, on a finely woven fabric, so that when ink is drawn across it, it is able to pass through the screen only in the desired areas. While the cost of screens for each new job is relatively small, the process itself does not allow rates of production comparable with methods of roller printing. Because of low cost, however, smaller yardages can advantageously be printed by the silk screen method. Silk screen inks are designed to dry relatively slowly in order that clogging of screens does not occur. Colors must be printed singly and sheets stacked for either forced-drying or air-drying, to avoid smudging. The silk screen method is employed for producing low-volume specialty products and is in wide

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Surface printing

Surface printing is a rotary printing process using raised engravings and permitting application of up to twelve colors without drying between nips. Ink is furnished to each printing roll by a fabric-covered roll which is in turn supplied by a metal roll immersed in an ink fountain. The printing rolls are mounted around the circumference of a large drum on which the plastics film travels. The relatively slow rate of production and lack of demand for surface-printed plastics have tended to diminish its use as a method of decorating plastics.

Transfer printing

Transfer printing involves applying a printed pattern, usually by gravure, to a carrier (generally a special coated paper), and then transferring the print to a film. This is a very useful method of maintaining precise register in cases where the plastics to be printed is subject to severe distortion either because of normal press tension or because of the solvent content of the inks used. The transfer-printing operation is usually accomplished by casting a plastics film on the printed carrier. The print releases from the paper, becoming an integral part of the film and bearing the exact pattern which is printed on the carrier.

Transfer printing is not used very extensively in the plastics industry, its principal applications being in the decoration of various soft plastics films, one mil or less in thickness.

Roll leaf stamping

Another type of transfer printing generally used for decorating small plastics sheets is roll leaf stamping. Roll leaf is available in continuous rolls of varying widths. It is made by coating colored ink compositions on a nonadhesive carrier, usually cellophane. This process also involves the transfer of ink from a carrier to a plastic. The transfer in this case, however, is effected by the application of a raised heated steel design to the roll leaf when in intimate contact with plastics. Whereas transfer printing is designed for production of continuous rolls of printed plastics, roll leaf stamping can be used only to imprint patterns on a single sheet of plastics in each printing cycle.

Spanishing

Spanishing, a carry-over from leather finishing, is a method of depositing ink in the valleys of embossed plastics. This is done mechanically either by a wipe-roll machine or by a knife-on-blanket unit. In a few plants, hand-spanishing of specialty plastics products is also carried on. The process is a highly practical procedure for producing two-tone effects in the limited number of applications in which design prohibits the use of valley printing. The use of spanishing is tending to diminish, because of the fact that valley-printing methods can produce the same effects in a single operation.

Embossing processes

The art of embossing is used to create depressions of a specific pattern in plastics film and sheeting in order to enhance the appearance and acceptability of plastics for consumer products. The three principal methods of embossing are: 1) pressure embossing; 2) vacuum embossing; and 3) dielectric embossing. Pressure-embossing techniques are well-known in the plastics industry. Vacuum embossing and dielectric embossing are relatively new processes which are finding wider use as their arts improve.

Pressure embossing

Pressure embossing is accomplished by both flat plate and rotary methods. Because of its relatively slow rate of production, plate embossing is generally limited to short runs. The actual operation is performed in a hydraulic press equipped with a heated platen, which is usually the upper platen. The engraved metal plate is clamped to this platen and is heated by it. When the sheets or continuous rolls of plastics are positioned in the

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press, either mechanically or manually, the lower platen forces the plastics against the pattern of the engraved plate. The rapidity with which the plastics take on the pattern of the engraved plate depends on the temperature of operation and the gage of the plastics. The permanence of the embossing depends also on the temperature, pressure, dwell time, and engraving depth. Naturally, these factors vary with each type of plastic material to be embossed.

The more widely used method of pressure embossing is roller embossing. The technique is similar in principle to plate embossing except that the pattern is engraved on the surface of a steel cylinder. This conversion permits continuous operation and, thus, higher production rates. In rotary embossing, the plastic is generally preheated and is fed between the engraved roll and a rubber pressure roll. The Durometer hardness of the rubber roll depends on the depth of the embossing required. The depth of the embossing, the gage of the plastic, and its flow point, all figure in determining the temperature and pressure required. Rapid cooling of the plastic is necessary to fix the impression permanently. This is done by cooling the embossing roll internally and, in cases where the gage of the plastic is very low, by spraying the plastic with cold water. Some manufacturers of vinyl sheeting have found it economical to have their embossing units directly in line with the calender so that goods are embossed as they pass from the calender.

Vacuum embossing

The technique of vacuum embossing permits the embossing of plastics much more deeply and less expensively than possible by pressure embossing. While first applied only to the embossing of plastics sheets, the process of vacuum embossing has been developed to permit the decoration of continuous rolls of plastics film or sheeting. In vacuum embossing, the material is first heated to its flow point by heaters within the unit. It is then drawn by means of vacuum against the

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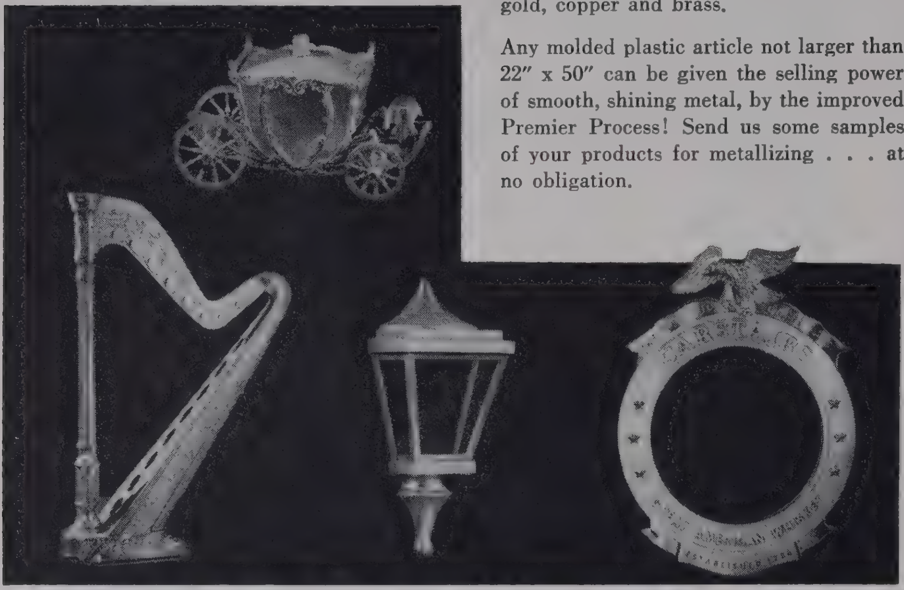

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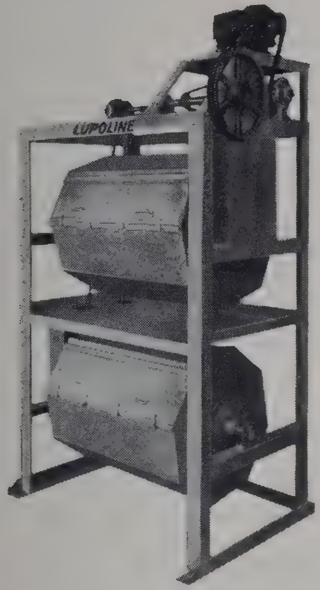

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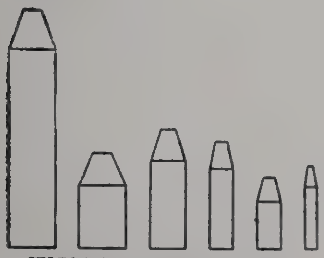
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mold which contains suitably positioned vacuum holes. As a result of the pressure exerted against the plastic, it takes the shape of the mold. Molds may be fabricated of such low-cost materials as plaster of paris. Unique effects are also obtained by using textile fabrics as molds. Items produced by this technique are place mats and acrylic outdoor advertising signs.

A major expansion in the use of vacuum-embossing techniques was made possible by the development of continuous, rotary vacuum embossing. This has permitted a large increase in production rates and, as a result, has been applied with great success to thin-gage polyethylene film. In the rotary vacuum-embossing process, the embossing roll is engraved in the reverse manner of a pressure embossing roll and is also drilled with vacuum holes. When the preheated plastic is passed over the chilled embossing roll, it is drawn against it, acquiring the pattern desired. A spray of cool water, applied immediately after embossing, serves to set the pattern. This additional cooling is especially necessary in the vacuum embossing of thin-gage plastics. Representative of the items produced by this method are inexpensive, highly styled, polyethylene draperies and tablecloths.

Dielectric embossing

Dielectric embossing is a by-product of dielectric heat-sealing. A heat-sealing machine is designed to heat plastics by means of high-frequency electric current. The current causes the plastics to heat up only where contacted by steel jaws of the desired design, which the heat-sealing unit presses onto the plastics. Quilted products containing a variety of stuffing materials, as large as entire automobile door liner assemblies, are produced by this technique. The process is discontinuous and operates on a definite time cycle which is determined by the voltage applied and the dwell time required to achieve a satisfactory weld. Successful production is possible only where the plastics and any print or coating applied to the plastics

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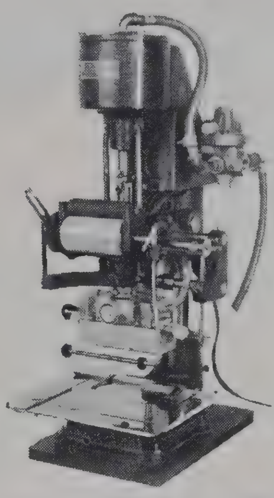
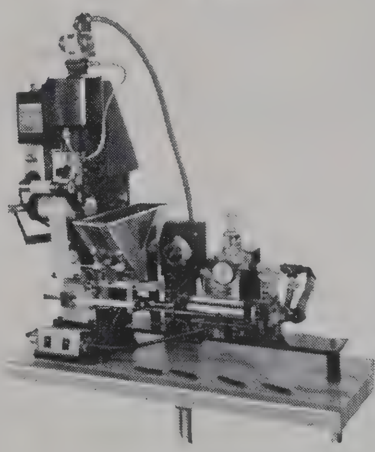


Illustration of Model AC-1 AIR OPERATED HOT PRESS STAMPING MACHINE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do not transmit electric current and hence permit arcing. Such arcing during the welding cycle can cause severe scorching of the plastics at the points of local current flow. Arcing is attributable to a wide variety of causes, among them high humidity and the use of a conductive printing ink in the area to be sealed. When an arc forms, it carbonizes the plastic film, producing a conductive path and then complete breakdown of the plastic. Obviously, weak or conductive spots in the plastic itself may also start this trouble. The ink pigments which are principally responsible for arcing troubles are carbon blacks and metallics (aluminum and bronze flakes). It has been found possible, however, to formulate these materials so that electronic heat sealing of jet black, gold, and silver prints can now be accomplished without arcing.

Because of the number of unknowns still present in the dielectric-sealing process, the choice of plastics and inks used by manufacturers is quite important.

Printing inks

Inks are generally formulated to suit a specific plastic, printing method, and product application. The printer's first concern is therefore his ink formulation. This must be considered from two aspects: 1) how the ink prints; and 2) how the print stands up on the plastics under subsequent manufacturing and actual use. Plastics inks are composed of blends of various synthetic resins, pigments, and solvents. Most plastics inks dry by evaporation of solvent. Ink solvents must be selected which will permit the inks to dry slightly faster than required by the speed of the printing operation. Through the use of retarding solvents, inks which are formulated properly can always be made to dry more slowly whereas inherent drying speed cannot be increased. A stream of rapidly flowing hot air passing over the printed plastics will provide maximum flexibility and speed, particularly, in multicolor gravure and flexographic printing. The temperature of the air is limited by the heat distortion point of the plastics.

Because of the complexities involved, users of printing inks would do well to check with suppliers before going ahead with a particular job.

Laboratory tests

There are no practical laboratory tests for reliably determining printing performance except by actual printing trials on laboratory equipment. In these trials, the printer determines the printing speed best suited to the specific inks and plastics, as indicated by the cleanliness of printing and the feasibility of printing one color over another. Standard equipment, which has been generally adopted in the industry, is available for performing laboratory tests to approximate the performance of printed material under conditions of actual use. Following are some of the tests which should be performed on printed plastics by the printer.

1) *Light fastness:* This test is usually performed using a standard Fadeometer or weatherometer, sometimes supplemented by outdoor exposure data. The light-stability requirements are determined by the product's end use. Specifications range from the 100 hr. or less of stability-to-light required by materials intended for indoor use to the 400 hr. of light-resistance demanded of outdoor products. Except possibly in the case of over-all pigmented coatings, the printer should not require greater light stability for his inks than the plastic itself demonstrates.

2) *Block resistance:* The block resistance of an ink is a measure of the degree to which it will tackify under conditions of heat and pressure. Most printed plastics are exposed to both heat and pressure at some time following the printing operation. Under such conditions, a normally block-resistant ink may show severe blocking.

(Blocking is sometimes confused with "mark-off," the latter being a condition wherein a print is incompletely dried and consequently transfers to any other surface which it contacts. If the printer uses inks formulated to permit complete solvent release on presses adequately equipped

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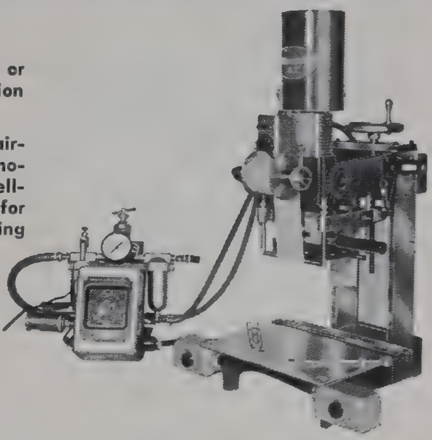

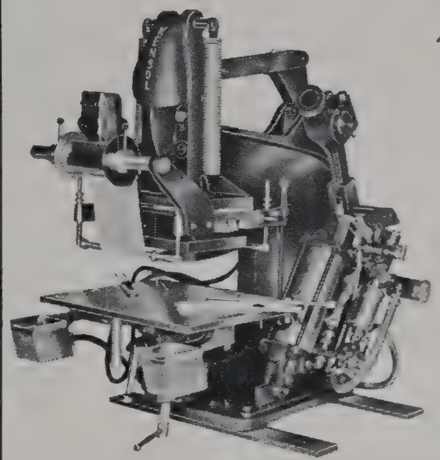

MEDIUM-WEIGHT
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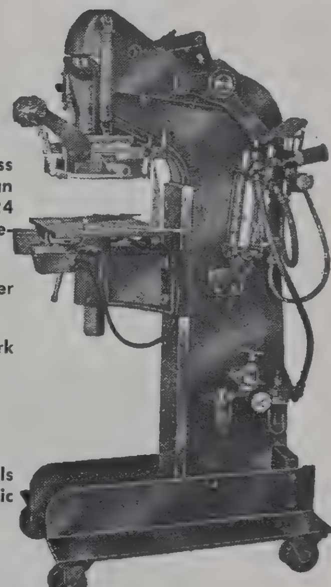

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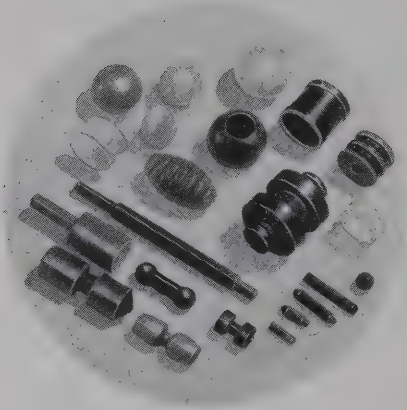

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with forced-drying equipment, he can completely eliminate the problem of mark-off.)

The usual test for blocking is an accelerated one using elevated temperature and pressure. Prints are placed both face-to-face and face-to-block between smooth surfaces. The resulting sandwich is placed under a measured pressure in an oven of controlled temperature for a specified time. If a printed plastic is to be embossed, it is necessary for the block point of the print to be as high as possible so as to avoid pick-off of the print by the embossing roll. On the other hand, where clear plastic is to be laminated to a printed plastic, best results require that the block point of the ink be as low as practical yet not interfere with the ink's working properties.

While the foregoing block test procedure is the most widely employed in the evaluation of vinyl printing inks, a different type of block test has also been found useful. This involves applying pressures up to several thousand lb./sq. in. at room temperature, or slightly above, for periods of 15 min. to one hour. In the case of pigmented inks of low film strength, this procedure tends to reveal any likelihood of color offset—backprinting or markoff—due to a failure akin to crocking.

This test method is designed to duplicate the high pressures which commonly occur in two ways in standard printing procedures. First, prints are usually subjected to pressure because of the practice of stacking rolls of plastic on skids for ease of handling. Second, it has been found that "plastic memory" causes shrinkage of the roll during the cooling period after printing. This shrinkage develops internal pressures in individual rolls of plastic which are in the order of several thousand lb./sq. inch. It has been found that this test shows up the true lack of adhesion of a highly filled ink which actually exhibits mark-off in printed rolls, while this same type of ink submitted to a conventional block test would exhibit apparent excellent block resistance because of the non-tacky nature of an ink film having high filler content.

3) *Crock resistance:* The crock resistance of an ink is a measure of its ability to resist transfer of color to any surface in brief contact with the print. Crocking is actually a condition of color transfer resulting from improper choice and combination of ink ingredients. Crocking of metallic inks can be eliminated by the addition of reducing clears to the inks prior to printing. Of particular interest to vinyl gravure printers has been the development of crock-resistant gold inks.

Crock resistance can be determined by means of the AATTC standard crock test which involves abrading a printed surface with another surface, which is usually a standard grade of textile fabric, for a specific number of times and at a fixed pressure. This determination is relative, thus requiring that the printer establish standards of crock resistance for himself as reference points. Where a printed plastic is either to be coated with a clear top coat or is to be covered by a clear laminate, crock resistance is of little consequence.

4) *Bleeding resistance:* The bleeding resistance of an ink is a measure of its ability to resist transfer of color into the printed substrate or to other surfaces as a result of prolonged and intimate contact. Because of the large variety of plastics in common use today, it is vital that inks be formulated with pigments which are bleedproof on almost all plastics. The tendency of an ink to bleed can be determined by an accelerated test using heat and pressure. (See tests described under block resistance.) Relative standards for bleeding should be established by the printer for reference purposes.

5) *Abrasion resistance:* The abrasion resistance of an ink is a measure of its ability to resist the effects of wear in actual use. Many plastics are relatively soft and cannot withstand extended abrasion. In cases where an ink shows poor abrasion resistance, the result can sometimes be traced to the low cohesive strength of the plastic itself. A standard testing machine to determine relative abrasion resistance is the Taber Abraser. By

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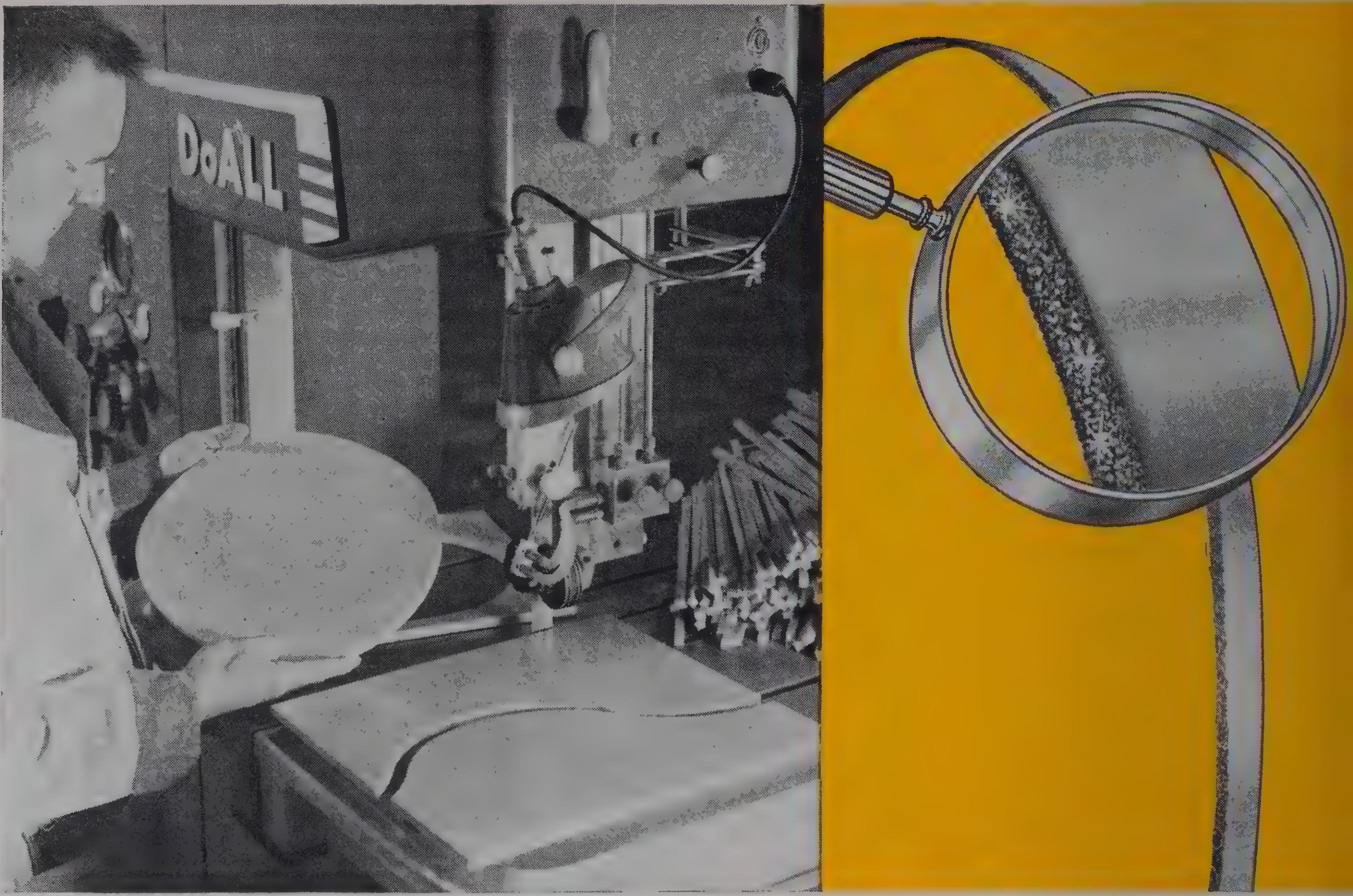

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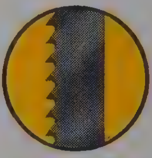
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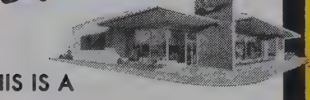
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means of this test equipment, abrasion resistance can be expressed in terms of the number of cycles required to reach a specific state of wear. There has been little correlation established between the results obtained in laboratory abrasion tests and the effects of actual usage. Abrasion tests, while only of relative significance, are still quite important as a guide to the plastics manufacturer.

6) *Soap resistance:* Numerous printed plastics products can be expected to come in contact with soap during their lifetime. The printer must be assured that his prints are alkali-fast. A simple test for this property involves immersion of the material in a 1% lye solution for 15 minutes. Retention of color can be judged by eye and will indicate the degree of soap fastness.

7) *Adhesion:* Many tests have been developed to determine the relative adhesion of inks to plastics. The test method most widely used is the pressure-sensitive tape test. This involves applying pressure-sensitive tape to a printed area of the plastics film or sheeting and then ripping the tape off. The quantity of ink removed by the tape is considered to be a measure of the adhesion which the ink possesses.

A number of objections to this test have been voiced. First, it is obvious that the test is in no way a reproduction of any field condition. Second, the test is as much a measure of the adhesion, or lack of adhesion, of pressure-sensitive tape to ink as it is a measure of the adhesion which the ink has for the plastics.

A second test method, commonly used in the packaging industry, which is more indicative of adhesion and toughness, is the "crinkle" test. In this procedure, printed plastic is grasped between the thumbs and forefingers of both hands, allowing approximately ½ in. clear material between the hands. Relative adhesion of the ink to the plastic can be observed after the motion of both hands in opposite directions for a given number of cycles wrinkles the film. Simple mechanical devices have also been developed to perform this test. Here

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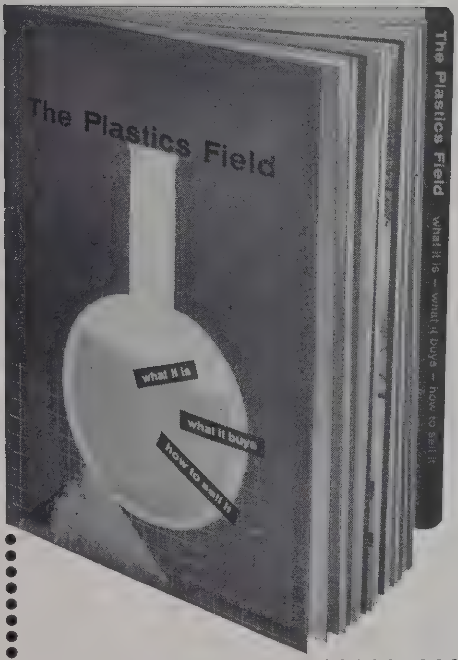
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again, relative standards can be set up to determine the quality of each ink.

Having assured himself of the quality of his inks, the printer's second concern must be for the uniformity and surface condition of his plastics material. Changes in the nature of the surface are often sources of printing problems. These can sometimes be traced to variations in manufacturing conditions or to changes in plastics formulations made for a specific purpose. An example of the first case is the irregular treatment of polyethylene film. An instance of the second case is the formulation of vinyl film with too great a proportion of spewing secondary plasticizers or lubricants. Only continuous testing by the printer and an appreciation of printing problems by the supplier will minimize these occurrences.

Standard test procedures for plastics printability can be established. One lot of ink, or one particular color, must be selected as a standard. Prints of this ink on batches of plastics should be subject to the various types of tests discussed above.

References

Consult the Subject Index for additional information on processes and equipment for decorating plastics film and sheeting. For sources of materials and of equipment for decorating film and sheeting, see Directory Index, p. 1078.

"Heat-sealing of polyethylene film," by R. M. Knight and W. U. Funk, Modern Plastics *35,* 133 (Dec. 1957).

"New method for treating film," Modern Plastics *35,* 286 (Oct. 1957).

"Valley printing on film," by H. C. Felsher, Modern Plastics *34,* 110 (July 1957).

"Metallized plastics expanding into new fields," Modern Plastics *34,* 252 (May 1957).

"Plastics steal the picture," Modern Plastics *34,* 141 (Mar. 1957).

"Surface treatment of moldings; Part I. Painting and lacquering," by M. Fuzzard, Brit. Plastics *28,* 413 (Oct.); "Part II. Hot-stamping, printing, and electrodeposition," ibid. 452 (Nov. 1955).

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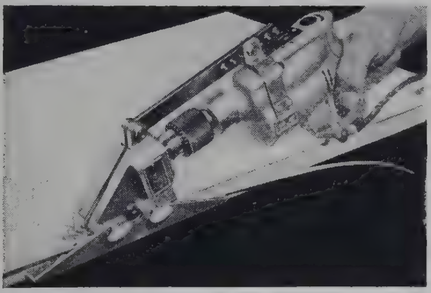

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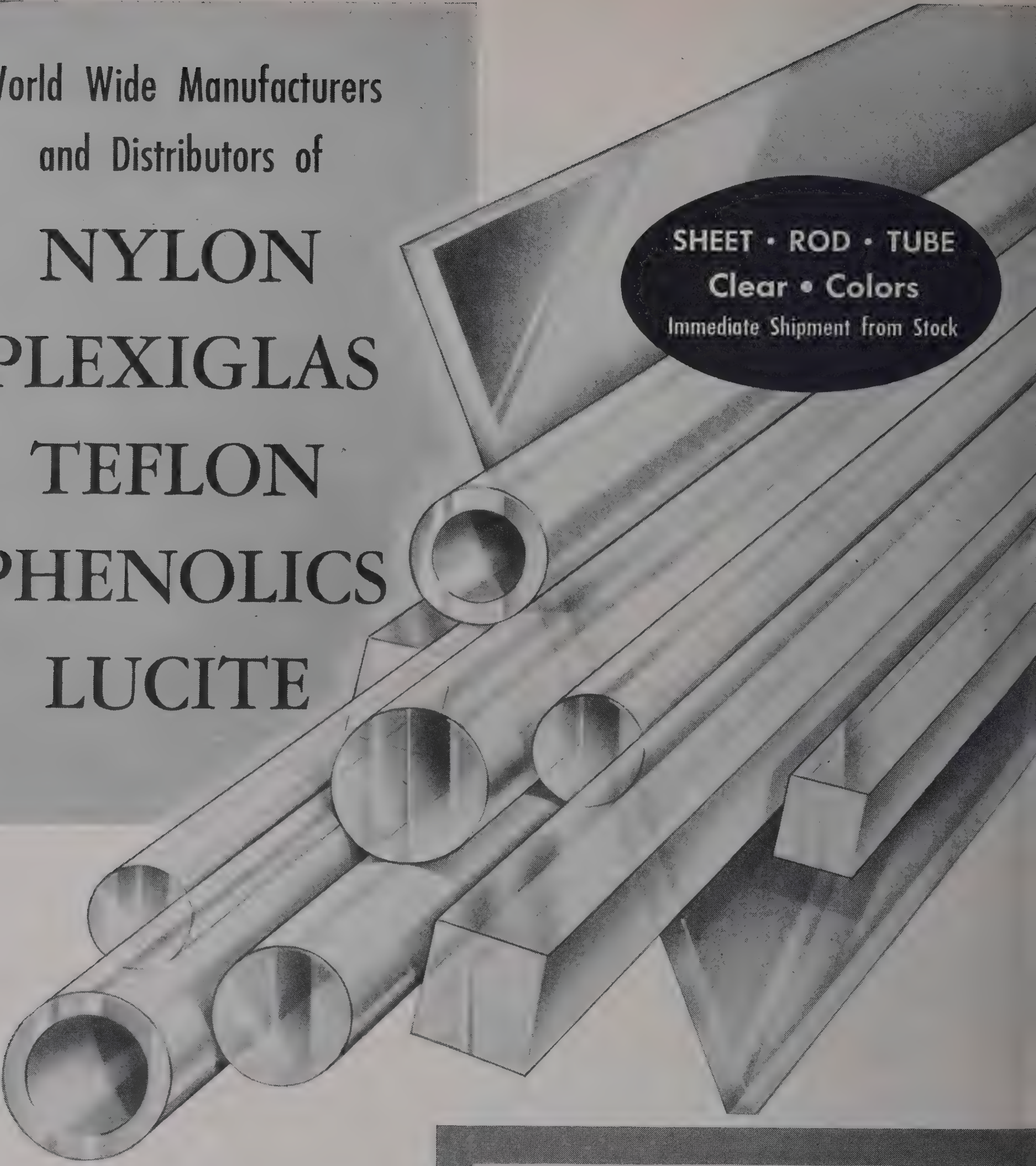

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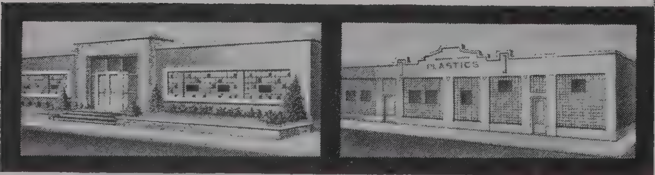

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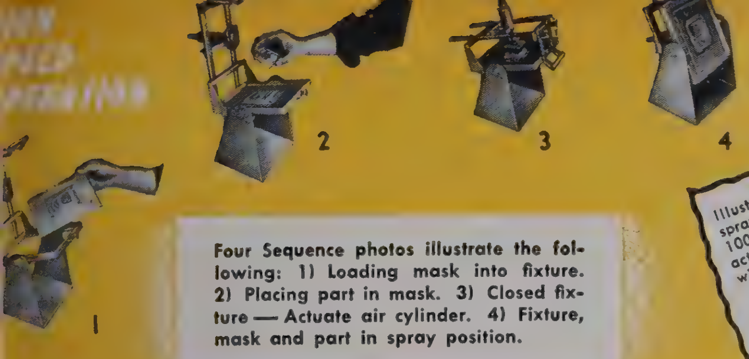
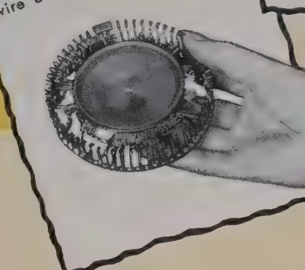
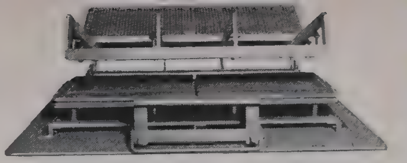


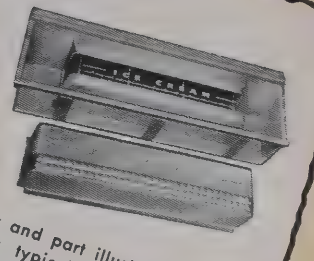
Four Sequence photos illustrate the following: 1) Loading mask into fixture. 2) Placing part in mask. 3) Closed fixture — Actuate air cylinder. 4) Fixture, mask and part in spray position.

Illustration shows a very delicate spray mask incorporating over 100 individual suspended characters on .040 diameter music wire bridges.





Two-tone air conditioning grille — mask and fixture adaptable to various size grilles.



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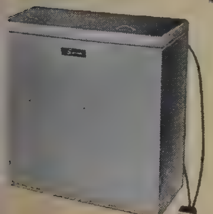
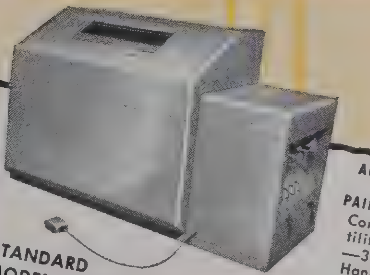


MODEL W-54-H

MODEL W-54-M

MODEL W-54-V



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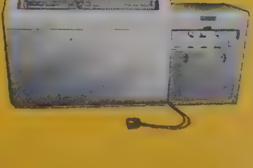

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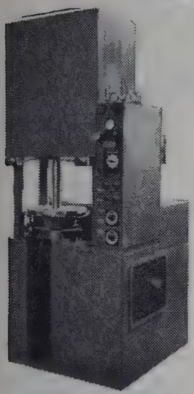
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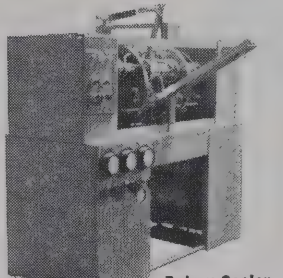
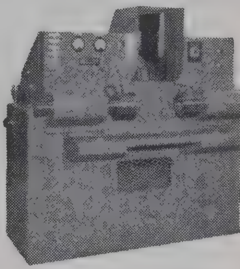

Rotary Sealer with automatic feed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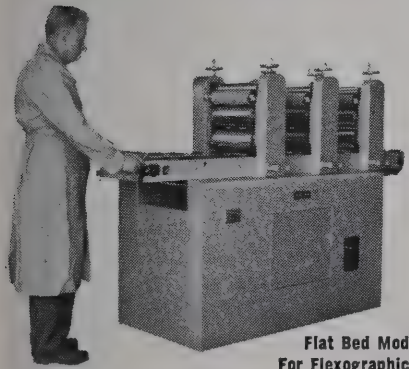
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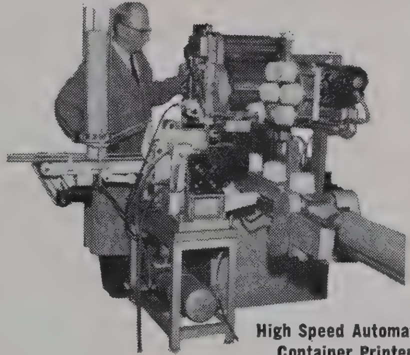
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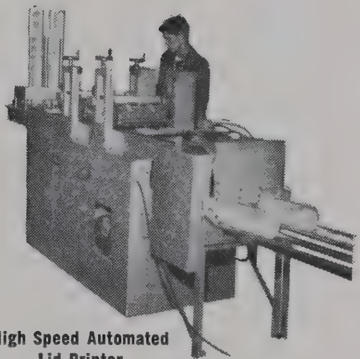
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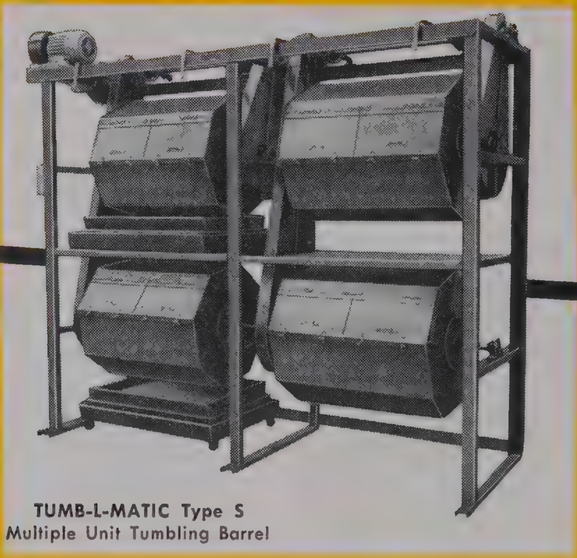

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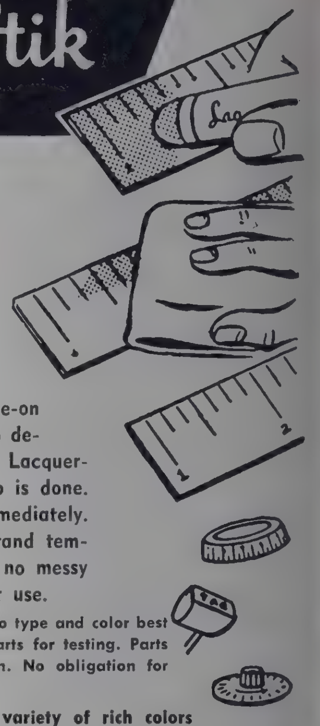

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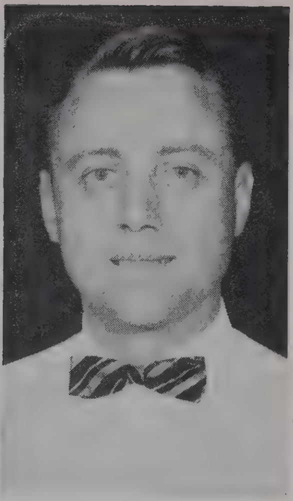

"NRC VACUUM COATERS INCREASE PRODUCTION UP TO 50%"

. . . says Jack Selsemeyer
Production Manager, Kent Plastics
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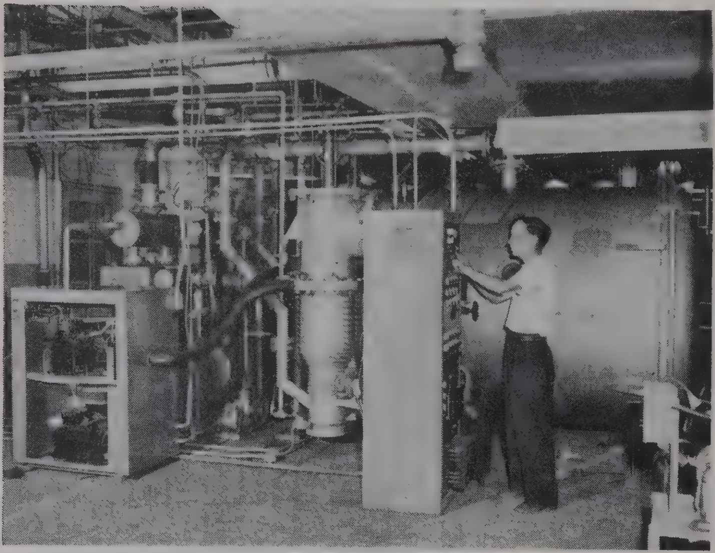
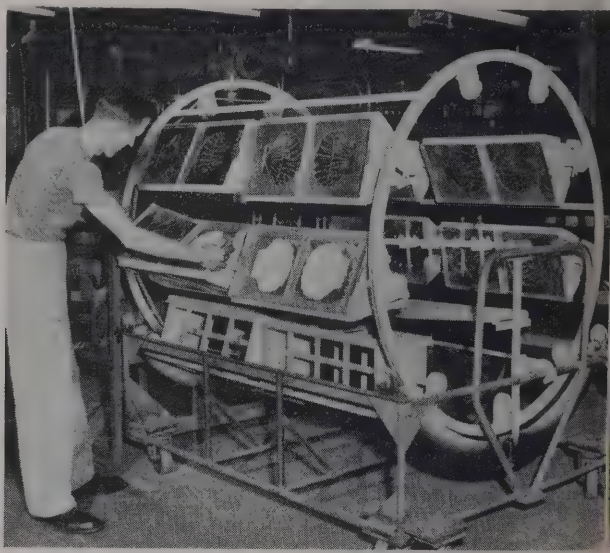
You too can avail yourself of the advanced knowledge and experience of NRC Equipment Corp. in the field of high vacuum coating. Write today for information about how we might be able to help you cut your finishing costs and improve quality.



"Fewer pieces have been junked and production increased with NRC Equipment. This firm has been a real help to us through their highly specialized knowledge in this field" — *Jack Selsemeyer.*



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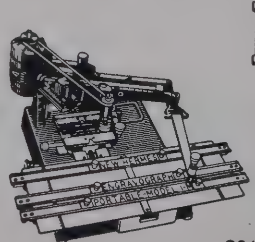

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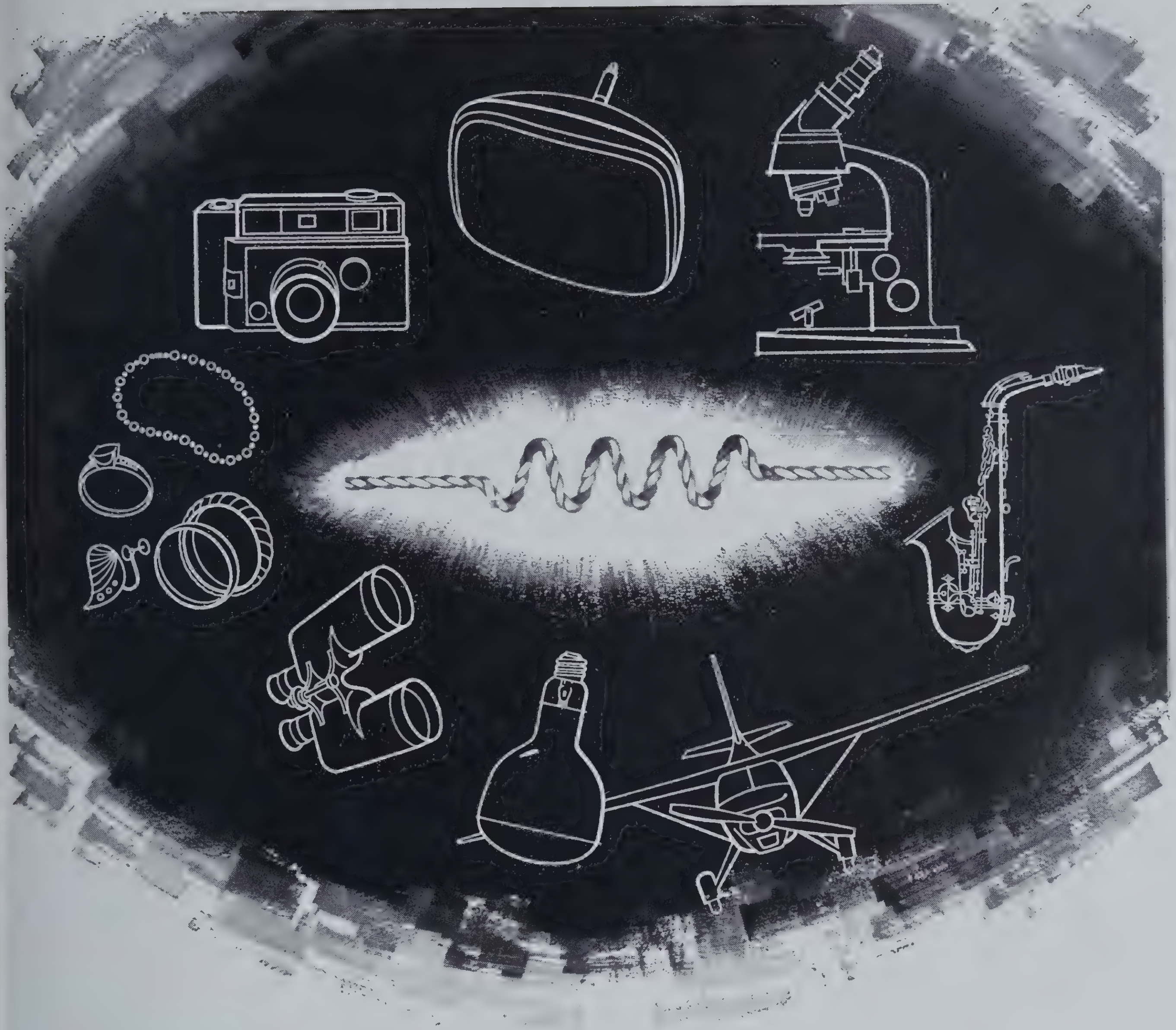

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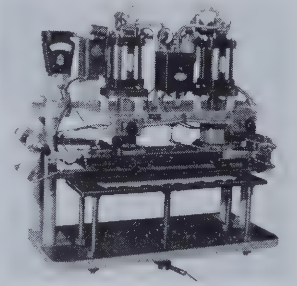

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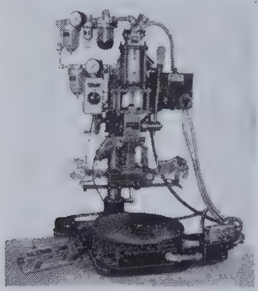
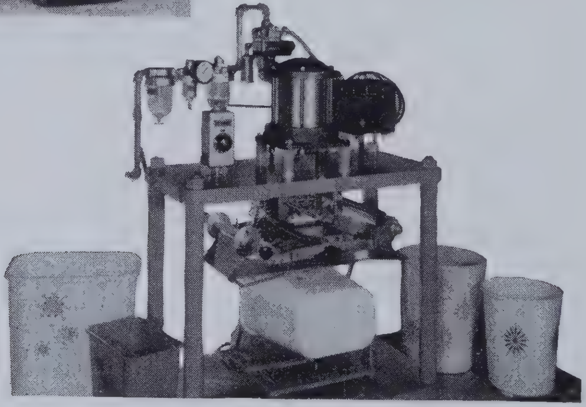


Model H-EAI Popular pneumatic electroair press for light parts of plastics or other materials. Index model for knobs or similar pieces. Platform model for flat or irregular shapes. Also, 4-post direct thrust model for larger parts.



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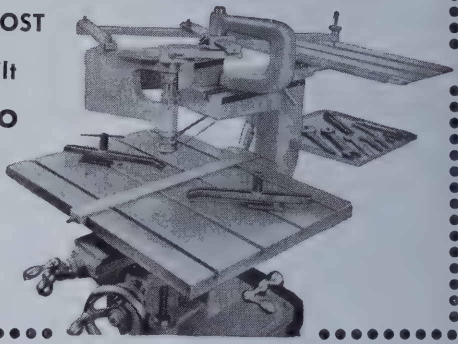

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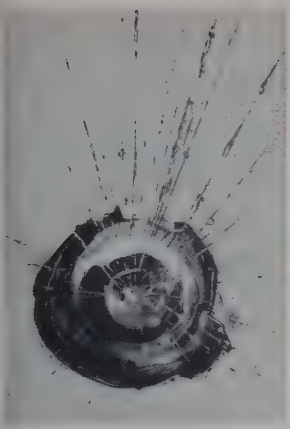

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Wood, R. D., Company	960, 961

OVENS & DRYERS

Acme Machinery & Mfg. Co., Inc.	992
Blue, E. B., Company	990
Brosites Machine Company Inc.	954
Goulding Mfg. Co.	1022
Industrial Ovens, Inc.	1039
Lydon Bros., Inc.	1020
Rainville Company Inc., The	1043

PACKAGING MACHINES

HAMAC Packmaschinen GmbH	1042A

PANTOGRAPHS

Mico Instrument Company	1001

PREFORMING MACHINES

Aust & Schuttler, Co.	868
B. I. P. Engineering Ltd.	1041
Bonnot Company, The	956
Erie Engine & Mfg. Co.	879
Hochman Plastics Machinery Corp.	965
Rainville Company Inc., The	1043
Stokes, F. J., Corporation	1035

PREPLASTICIZING UNITS

Covema s.r.l.	851
Farrel-Birmingham Co., Inc.	1018, 1019
Watson-Stillman Press Div., Farrel-Birmingham Co., Inc.	1014, 1015

PRESSES FOR REINFORCED PLASTICS

Erie Engine & Mfg. Co.	879
Lawton, C. A., Company, The	864
M & N Modern Hydraulic Press Co.	988

PRINTING PRESSES

Faeco Machine Co., Inc.	958
Hofmann & Schwabe K.G.	1021
Liberty Machinery Co. Inc.	966
Possis Machine Corporation	1034
Rainville Company Inc., The	1043
Waldron, John, Corporation	856, 857

PUMPS

Bolling, Stewart, & Company, Inc.	1010
Elmes Engineering Div., American Steel Foundries	1055
Hochman Plastics Machinery Corp.	965
Johnson Machinery Co.	965
Mico Instrument Company	1001

PYROMETERS

Cambridge Instrument Company, Inc.	962
Rainville Company Inc., The	1043
Thermo Electric Co., Inc.	1020

ROTATIONAL CASTING MACHINES

Akron Presform Mold Co., The	1017
Mercury Molding Machinery Inc.	968

SHEARS, CUTTERS & SAWS

Bandera, Luigi	979
Buss Machine Works, Inc.	1012
Engis Equipment Company	1029
Falls Engineering and Machine Co., The	955
Famco Machine Company	1024
Fecken-Kirfel Machinenfabrik Aachen (Germany)	990
Foster & Allen, Inc.	970
Goulding Mfg. Co.	1022
Injection Molders Supply Co.	1013
Johnson Machinery Co.	965
Robbins Plastic Machinery Corp., Subsidiary of Lynch Corp.	994, 995

SLITTERS, SHEETERS & REWINDERS

Appleton Machine Company, Doven Div.	1040
Associated Equipment Corporation	980
Black-Clawson Company, The, Dilts Div.	1012
Bolling, Stewart, & Company, Inc.	1010
Cameron Machine Company	861
Dusenbery, John, Company, Inc.	853
Falls Engineering and Machine Co., The	955
Goulding Mfg. Co.	1022
Hobbs Manufacturing Co.	992, 1016
Progressive Machine Co., Inc.	967
Robbins Plastic Machinery Corp., Subsidiary of Lynch Corp.	994, 995
Waldron, John, Corp.	856, 857

SPLICERS

Robbins Plastic Machinery Corp., Subsidiary of Lynch Corp.	994, 995

SPRAY EQUIPMENT

Binks Manufacturing Co.	974

STEAM GENERATOR

Pantex Mfg. Corp.	1001
Johnson Manufacturing Co., Inc.	1049

TAKE-OFF EQUIPMENT

Bandera, Luigi	979
Cameron Machine Company	861
Goulding Mfg. Co.	1022
H & T Machine Works, Inc.	844
Hartig Extruders, Div. Midland-Ross Corp.	854, 855
Johnson Manufacturing Co., Inc.	1049
Killion Tool & Manufacturing Co.	863
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Progressive Machine Co., Inc.	967
Robbins Plastic Machinery Corp., Subsidiary of Lynch Corp.	994, 995
Servospeed	963

TESTING EQUIPMENT & MEASURING DEVICES

Atlas Electric Devices Co.	970
Brabender, C. W., Instruments, Inc.	953
Scott Testers, Inc.	1029
Taylor-Emmett Controls, Inc.	1032, 1033
Testing Machines, Inc.	957

TOOL & DIE KITS

Cratex Manufacturing Co., Inc.	1034

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Battenfeld Corporation of America	996, 997
Bolling, Stewart, & Company, Inc.	1010
Daniels, T. H., & J., Ltd.	848
Elmes Engineering Div., American Steel Foundries	1055
Erie Foundry Co.	860
Farrel-Birmingham Company, Inc.	1018, 1019
French Oil Mill Machinery Co., The, Hydraulic Press Div.	1007
Hochman Plastics Machinery Corp.	965
Hull-Standard Corporation	973
Hydraulic Press Mfg. Company, The, Division of Koehring Company	880, 881
Karlton Machinery Corp.	1016
Lawton, C. A., Company, The	864
Logan Hydraulics, Inc.	1025
M & N Modern Hydraulic Press Co.	988
Stokes, F. J., Corporation	1035
Watson-Stillman Press Div., Farrel-Birmingham Co., Inc.	1014, 1015
Williams-White & Co.	982

TRIMMING PRESSES

Falls Engineering and Machine Co., The	955
Tronomatic Machine Manufacturing Corp.	864

USED & REBUILT MACHINERY

Dusenbery, John, Company, Inc.	853
Reliable Rubber & Plastic Machinery Co., Inc.	1054

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VACUUM & SHEET FORMING MACHINES

Air-o-flow Industries, Inc.	1048
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Brown Machine Company	972
Comet Industries	878
Rainville Company Inc., The	1043

VALVES, SEALS

Daniels, T. H. & J., Ltd.	848
Sinclair-Collins Valve Co., The	986
Taylor-Emmett Controls, Inc.	1032, 1033

WINDERS, SPOOLERS, CORES

Adamson United Company	858, 859
Appleton Machine Company, Doven Div.	1040
Black-Clawson Company, The, Dilts Div.	1012
Cameron Machine Company	861
Dusenbery, John, Company, Inc.	853
General Electric Company, Direct Current Motor and Generator Dept.	1008, 1009
Hobbs Manufacturing Co.	992, 1016
Progressive Machine Co., Inc.	967
Reliance Electric and Engineering Co.	1059
Waldron, John, Corporation	856, 857

Plastics problem got you down?

Get help in a hurry from your Encyclopedia Issue!

EXAMPLE: *Where and how to use resins and molding compounds?*

1. See the section "Resins and Molding Compounds" for all the fundamentals. Also see the materials charts and supplier lists in the "Technical Data" section.
2. Then check the Advertisers' Index—on the first page of the "Resins . . ." section—for suppliers' ads on resins, coatings, emulsions, etc.
3. Secure additional names and addresses of suppliers from extensive Buyers' Directory lists in the back of the book.
4. Consult the front-of-book Editorial Index for detailed cross-referenced listings of subjects related to your particular inquiry.
5. Check through the "Manufacturers' Free Literature" Section, select all possible helpful publications, and send for them with enclosed post cards.

EXAMPLE: *How to color plastics?*

1. See the section "Chemicals for Plastics" for complete background.
2. Next, refer to the front-of-book Editorial Index on the first page of the section for ads relating to your specific needs.
3. Check the Buyers' Directory for a detailed listing of suppliers of dyes, colorants, pigments, inks.
4. Consult the front-of-book, Editorial for detailed cross-referenced listings of subjects related to your particular inquiry.
5. Check through the "Manufacturers' Free Literature" Section, select all possible helpful publications, and send for them with enclosed post cards.

EXAMPLE: *How to design a product—then get it made?*

1. Get the basic facts in the section "Engineering and Methods".
2. Then for molder and special service advertisements, see the Advertisers' Index on the section's first page.
3. Next, examine the Buyers' Directory for additional names and addresses of molders, extruders and service organizations.
4. Consult the front-of-book Editorial Index for detailed cross-referenced listings of subjects related to your particular inquiry.
5. Check through the "Manufacturers' Free Literature" Section, select all possible helpful publications, and send for them with enclosed post cards.

EXAMPLE: *Which machinery to buy?*

1. Turn to the section "Machinery and Equipment" for a complete picture of the factors involved.
2. Then see the Advertisers' Index on the first page of this section and select ads whose messages bear on your problem.
3. Get further information—names and addresses of machinery, machine tool and equipment manufacturers—in the time-saving Buyers' Directory.
4. Consult the front-of-book Editorial Index for detailed cross-referenced listings of subjects related to your particular inquiry.
5. Check through the "Manufacturers' Free Literature" Section, select all possible helpful publications, and send for them with enclosed post cards.

The Encyclopedia is expressly designed to help you solve your problems. Reach for it next time you need help and see how valuable it can really be!

MODERN PLASTICS ENCYCLOPEDIA ISSUE

. . . for fast, accurate answers to plastics problems

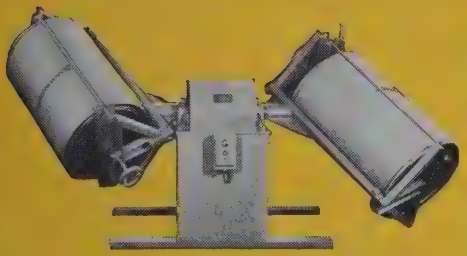
machines do the job best!

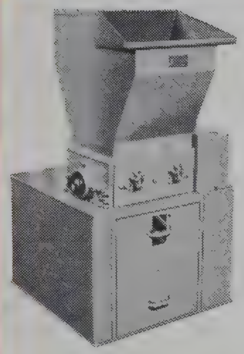
GRANULATORS

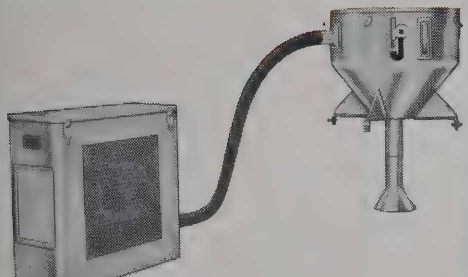
HEATER-DRYERS, PELLETIZERS, BLENDERS AND DRUM TUMBLERS, TOO

Performance counts . . . and, on-the-job, B&J Granulators outperform all others of comparable size and cost. For beside-the press, you can't beat B&J Marvel Series Granulators —built entirely of steel with capacities up to 500 pounds an hour. For large volume batch grinding or for handling the toughest thermoplastics, your best buy is a B&J Steelmaster Granulator. For intermediate requirements, there are many other models to choose from. Compare performance . . . compare construction . . . compare cost—you'll see why Ball & Jewell has been the leader in granulating machines for more than 60 years.

STEELMASTER—Makes the toughest grinding jobs easy. Heavy steel plate construction throughout.


DRUM TUMBLERS
Floor level loading. Accommodate 28" to 37" drums. Ball bearing equipped. Extra heavy steel construction throughout.


MARVEL SERIES GRANULATOR
Models with capacities from 75 to 500 pounds an hour. Constructed of steel.

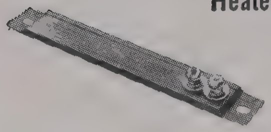
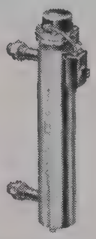
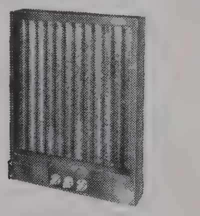
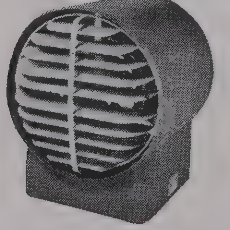

HEATER-DRYER (HOPPER ATTACHMENT)
Disperses moisture and preconditions material. Helps eliminate rejects and increase production. Steel or Stainless Steel Construction.

BLENDOMATIC GRANULATOR
Mixes virgin material with regrind as the regrind is generated, then loads mixed material into extruder or molding machine hopper.

BALL & JEWELL, INC.

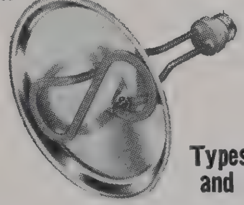
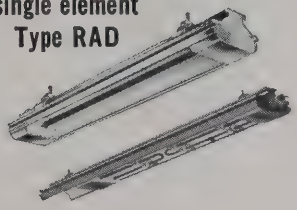
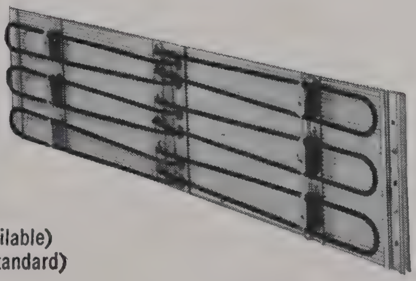
22 FRANKLIN STREET, BROOKLYN 22, N.Y. EVergreen 9-6580
Exclusive Export Distributors: Omni Products Corp., New York, N.Y.

CHROMALOX Electric Heating Equipment

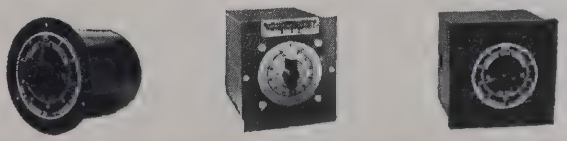
Chromalox Element	Where to use	Design features	Sizes—Ratings
Strip Heaters 	Process machines, ovens, drums, dies, platens, pipelines, rolls, kettles, tanks, cylinders and nozzles. Air heating, industrial drying, preheating.	Easy to install with clamping bands or standard bolts and heavy duty clamps. Available curved lengthwise or in cross-section. Provides heat where you need it at accurately maintained temperatures. Nickel chromium resistor embedded in refractory which is hydraulically compacted to maximum density and rock-hardness, and enclosed in metal sheath.	Volts: 120, 240, 480 Watts: 100 to 4500 standard ¾″, 1″ 1½″, 2½″ widths. Lengths up to 96 inches Terminals, sheath material and auxiliary hardware to accommodate your requirements.
Cartridge Heaters 	For localized heating in work areas requiring close thermal control such as: Dies Platens Molds Extrusion and Injection Barrels	Refractory-imbedded element in straight, accurately finished sheath. Sized to slip smoothly into standard drilled openings. Brass sheath is standard. Inconel available for higher temperatures. Flexible wire leads and bolt-type terminals available. Special devices to protect heater leads against flexing action, abrasion, moisture or vapors.	Diameters: ⅜″ to 1¹⁹⁄₆₄″ Overall lengths: 1⅝″ to 24⁵⁄₁₆″ Watts: 30 to 4600 Volts: 120 and 240 Special sizes and ratings to order
Finstrip and Microfin Elements 	Forced air ducts, blower units, ovens, dryers	Finstrip and Microfin heaters offer additional element surface for fast conduction of generated heat to air blast. Both can be formed to concentrate heat. Microfins, because of slim diameters, offer faster heatup and responsiveness where needed. Available in 750°, 950° and 1050° F. construction.	Finstrips: 120 and 240 volts. 250 to 4150 watts. Finned lengths: 6¼″ to 37¼″. Microfins: 120 and 240 volts. 475 to 3950 watts. Finned lengths: 7½″ to 49½″.
Circulation Heaters 	For accurately controlled heating of water, oils, heat transfer media, steam, air or other gases, heating rinse water, steam accumulators, process kettles, shower and washrooms, preheating fuel oil.	A complete heat package with built-in elements; rugged, corrosion-resistant, steel pipe heating chamber; full insulation; heavy gauge steel jacket; thermostat; two sturdy mounting lugs; pipe connections. Explosion- and moisture-resistant terminal covers for special conditions.	Water: 1½ to 100 kw. Oils: 3 to 40 kw. Dowtherm, Aroclor, Prestone: 1½ to 40 kw. Steam, air and other gases: 1 to 84 kw. Most sizes available from stock in either 240 or 480 volts, single or three phase Special sizes to order
 **In-duct Type Heaters**	For mounting in ducts, where air is heated under forced circulation: Ovens Dryers Space heating Process work requiring heated air blasts.	Heater consists of banks of finstrip elements mounted side by side in a steel frame. Finstrips are mounted with edges toward the direction of air flow. Mounting holes provided on both sides. Terminals on either bottom or side. Removable terminal covers available.	120, 208, 240, 480 volts single or three phase 6 to 100 kw.
Blower Type Unit Heaters 	For larger areas requiring greater amounts of heat distribution. Suitable for factories, garages, machine shops, and drying rooms.	Twin centrifugal fans draw air across bank of Fintube® heaters. Air deflectors discharge warm air downward. Inlet and outlet openings are adaptable to ductwork. Removable panel provides easy access to wiring and blower. Blower can be used with separate circuit for summer cooling. Thermal cutout provides protection against overheating. Manual reset switch.	240 and 480 volts three phase, 60 cycles only 15 to 50 kw.

supplies the electrical answer for every heating problem to temperatures of 1200°F. The world's largest stock, over 15,000 standard items, is ready for immediate shipment.

In most cases, Chromalox heating equipment can be applied using calculation data prepared. A nationwide network of Chromalox Sales-Engineering Representatives is ready to help you with those applications requiring special engineering and manufacture. Let us know which heaters you are specifically interested in and we will send you more detailed information. Edwin L. Wiegand Company, 7613 Thomas Boulevard, Pittsburgh 8, Pa.

Where to use	Design features	Sizes—Ratings	Chromalox Element
Pipes, vats or irregular surfaces, fuel oil, electroplating, dies and molds, pipelines, valves.	Hi-temp Thermwire consists of a loop of high quality nichrome resistor covered with a thick uniform layer of heat resisting silicone rubber. Provides high dielectric strength and resistance to moisture, abrasion and corrosion.	120/240 volts AC Operating temperatures up to 375° F. Thermostats and input controllers for complete automatic control	**Hi-Temp Thermwire**
Annealing Calendering Curing, Conveyorized Drape forming Drying coatings Drying silk screening Drying and preheating granules Drying and curing plastic loaded glass mat Drying reinforced plastic preforms Embossing Forming and shaping Fusing of cast films and sheets Heat sealing Ink drying, Paint drying Laminating Planishing & polishing Postforming Slush molding Transfer molding Resin curing & finishing Setting paper additives Setting paper coating Vacuum forming Vinyl fusing	The Metaray® lamp replacement element is an adaptation of the metal-sheath Far-infrared heater. It is designed to replace glass-enclosed lamps in all types of lamp-bank installations. Provides more uniform work coverage because the heat source is not localized in a small, hot filament, but is dispersed in a large figure 8 pattern providing more uniform heat on the work. Withstands thermal shocks from splashed liquids and other rough usage.	G-30 lamp equivalents: 375 watts, screw base 500 watts, screw base Screw base: R-40 lamp equivalents; 375 watts for double wall ovens; 375 and 500 watts with built-in reflector T-40 lamp equivalents: 600 watts, bi-post base; 1200 watts, bi-post base	**Metaray® Far-Infrared Lamp Replacement Units**  **Types FR and FRB**
	Radiation is in a straight uniform band, ideal for heating large areas. Heat source is a tubular element mounted in an extruded aluminum base with a polished aluminum reflector. Element is mounted on secondary insulating bushings. Housing is equipped with two removable sliding mounting clamps which provide flexibility in mounting under a variety of conditions. Type RAD has single straight element. U-RAD elements are hairpin-shaped giving double intensity per lineal inch.	Heated lengths: $8\frac{5}{16}''$ to $185\frac{5}{8}''$ Watts: 800 to 13,000 Volts: 120, 240, 480 Special models up to 30 feet Hermetically sealed units for contaminated atmospheres, also moisture-proof models	**Radiant Heaters, single element Type RAD**  **double element Type U-RAD**
Vacuum forming Pre-heating Drying Curing Baking Dehydrating Heat-setting Setting coatings Vinyl fusing Each panel has 100 amp. full-length 3-phase bus with links for inter-panel connection.	Mounting brackets pre-drilled for easy installation and panel-to-panel bolting. Corrugated aluminum coated reflector easily removed for cleaning. Fully insulated to keep heat on the job. Uniform high intensity, far-infrared edge-to-edge heat.	2 standard widths: 12 and 24 inches 2 standard lengths: 48 and 66 inches (special lengths available) 6 or 12 elements (standard) 240 or 480 volts 1800 or 2500 watts	 **Radiant Panels**

Chromalox Type VC Input Controllers are cycling devices that automatically control the percentage of time the electrical heating circuit is closed. Operation is on a thirty-second cycle with the dial calibrated in the percentage of time "on" for each cycle.



Chromalox Type AR Thermostats—Rugged industrial type that provides precision control of operating temperatures. Adjustment from 50° to 550°F. Complete with length of capillary tube, housing and mounting fixtures.

CHROMALOX

Electric Heat

INDUSTRIAL • COMMERCIAL • RESIDENTIAL

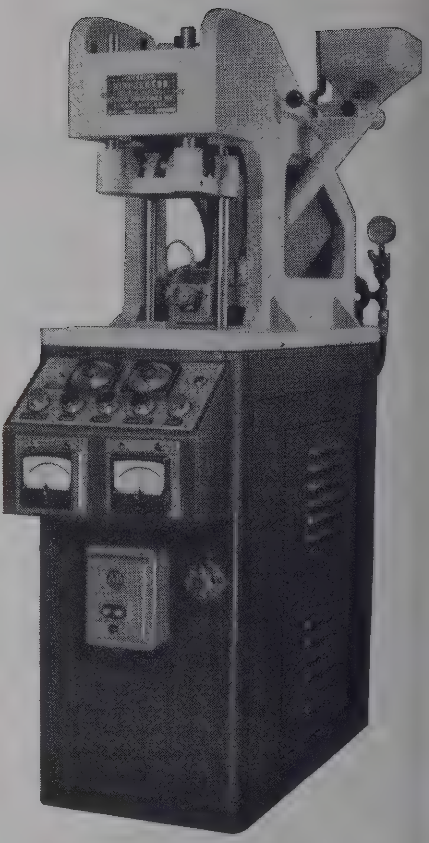
EDWIN L. WIEGAND COMPANY
7613 Thomas Boulevard • Pittsburgh 8, Pa.

For profitable plastic injection molding especially of parts involving inserts or loose cores . . . the

"ELDORADO"
MINI-JECTOR

Reg. U.S. Pat. Off.

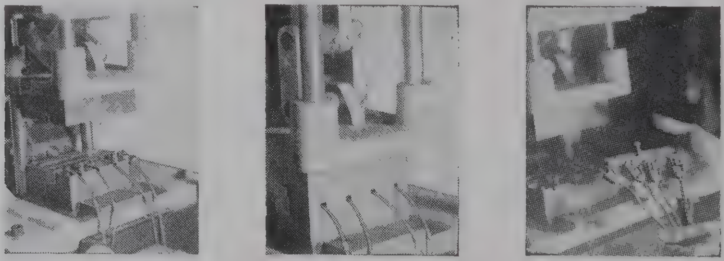
Plastic Injection Molding Machines



Super "Eldorado" MINI-JECTOR, model 70VC105 (above), offers semi-automatic operation in addition to all the advantages of the Standard "Eldorado," model 70VC95 which is lever controlled.

"Eldorado" MINI-JECTORS are designed to solve a specific injection molding problem. They are the ideal answer to fast, low-cost production of parts up to 1½ oz. especially those involving inserts or loose cores. "Eldorado" MINI-JECTORS are daily molding a wide variety of precision parts in all thermoplastics.

The "Eldorado" MINI-JECTOR is hydraulically operated and is available either with lever controls or for semi-automatic operation.



Typical example of insert molding on "Eldorado" MINI-JECTOR. *Left*—Close up of mold in open position. Note unobstructed access to mold area. *Center*—Close up of mold in closed position. *Right*—Cycle completed. Molding of cord endings shown represents only one of hundreds of applications, but as they are familiar objects, it is easy to visualize the capacity range of "Eldorados."

You'll like these outstanding "Eldorado" features:

- *No front tie rods* to hinder operator's easy access to mold area when mold is open.
- *Vertical Clamp Operation*—Inserts or loose cores remain undisturbed because bottom of mold is always stationary.
- *Simple to Operate*—No special skill needed for efficient operation.
- *Hydraulic Power*—Self-contained Vickers hydraulic system powers mold closing and injection.

Here Are Quick Facts About MINI-JECTORS

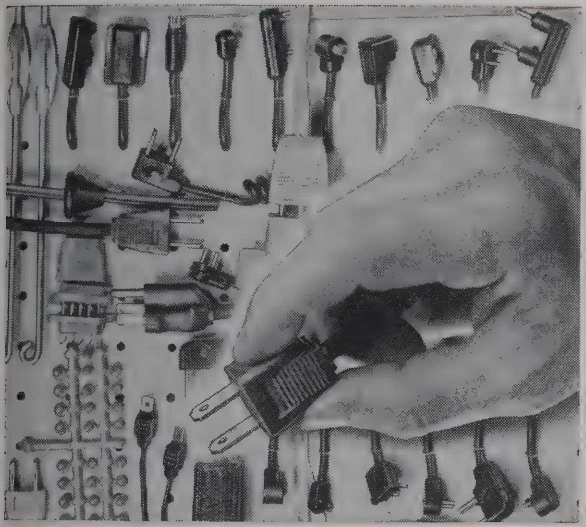
- MINI-JECTORS are designed for injection molding of any thermoplastic including nylon.
- The injection capacity of MINI-JECTORS ranges from tiny subminiature parts up to 1½ oz.
- You can make practically ANYTHING of thermoplastics in their capacity range on MINI-JECTORS.

Advantages of MINI-JECTORS

- You can make even short or moderate runs profitable on MINI-JECTORS.
- New products can be made quicker—usually before big press tooling could be off the design board.
- Award winning quality and precision even in complex parts involving loose cores or inserts. (Some owners mold parts involving tiny holes, slots, etc., all one-operation molded and they report that only a MINI-JECTOR could produce them.)
- You have a wide choice of models with many stock options. This is because we specialize in the capacity range up to 1½ oz. You can get the most economical model for the job—you don't have to "over-specify."
- Low first cost, prices start at under $1,000 for ¾ oz. capacity model complete and ready to operate. MINI-JECTORS pay for themselves many times over in savings alone.

Write for FACTS . . . fill in coupon and mail TODAY! →

MOLD THEM QUICKER, BETTER, FOR LESS on . . .



MINI-JECTOR *cuts cost for manufacturers* of electrical, electronic, industrial and commercial equipment. Wide variety (above right), all MINI-JECTOR produced, represents important savings over big press tooling where not required. All electrical and electronic parts (above) plugs, cord ends, antennas, miniature brush assemblies, slip rings, etc. (sub-miniature to 1½ oz.) made for less on MINI-JECTOR.

MINI-JECTOR

Reg. U.S. Pat. Off.

PLASTIC INJECTION MOLDING MACHINES

Quicker — Produce thousands of molded items usually before multiple cavity tooling is off design board.

Better — Award-winning quality and precision even in complex, insert molded designs.

For Less — Develop and produce molded items at fraction of big press tooling costs.

You can save thousands of dollars in mold costs alone with MINI-JECTOR (mold blanks as low as $29.50!). Others are doing it—avoiding big press "high-per-piece" tooling expense where not required.

MORE VARIETY AT LOWER COST

The more the variety, the bigger the savings. Flexible, efficient MINI-JECTOR plastic injection molding machines answer the critical need for lower cost development and production of fast-changing varieties of precision-molded plastic items. Savings begin with low initial machine investment (some under $1,000) and Mold blanks as low as $29.50.

More important are the major savings in time, trouble and money developing and producing wide varieties of items by eliminating complex, costly big press tooling where not needed. MINI-JECTOR solves your tight-margin runs.

Standard "Eldorado" Mini-Jector, left; "Hornet" model, up to 1 oz., center; "Wasp" model with self-clamping "V" mold right.

Send for FREE catalog—NOW!

New, illustrated. Shows low cost way MINI-JECTORS develop and produce wide variety of molded items (sub-miniature to 1½ oz.) in *all* thermoplastics by modern, more profitable methods. Over 50 pages of useful information . . . detailed specifications; technical data on performance, applications. Complete price list on all MINI-JECTOR models and accessories. Mail coupon today.

For convenience fill in name, clip to your company letterhead and mail

NEWBURY INDUSTRIES, INC.
Box 100, Newbury, Ohio

Name . . . .

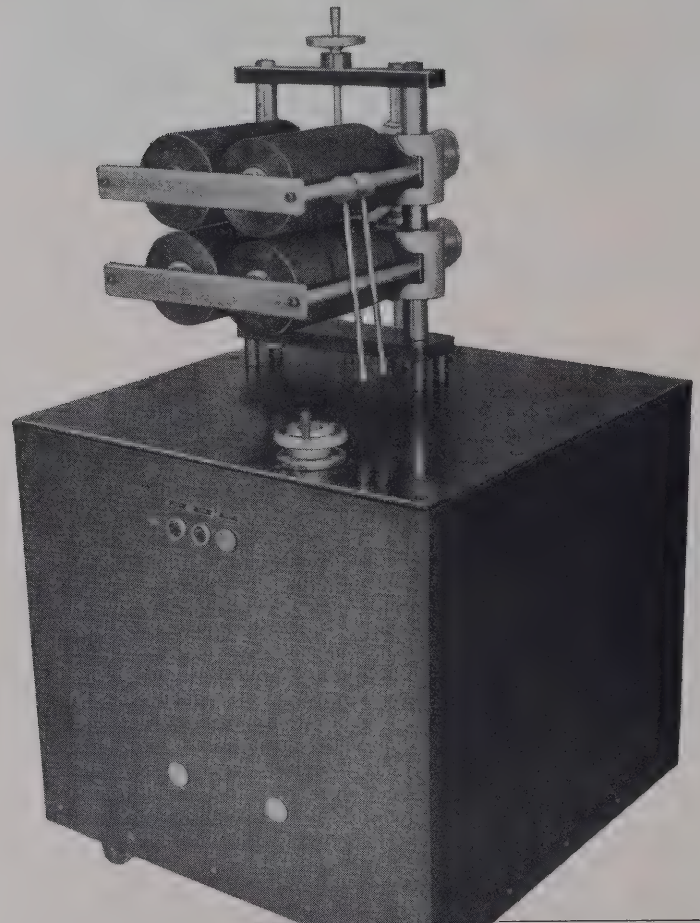
Company . . . .

Address . . . .

City . . . . State . . . .

Especially for CUSTOM EXTRUDERS...

Plastimaster take-off · FOUR DRIVEN ROLLERS for MAXIMUM DRAUGHT... MINIMUM PRESSURE

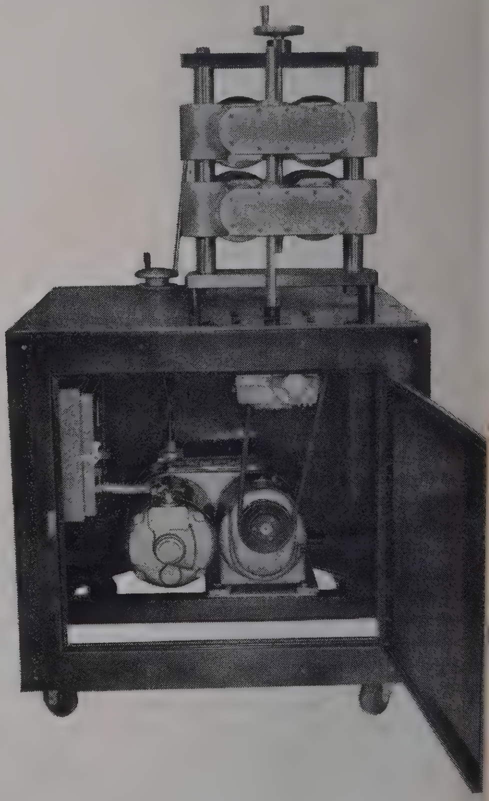


The Plastimaster Takeoff was developed in a extrusion plant, to meet the specific needs o the custom extruder. One of these is the im proved control over distortion offered by fou driven rollers.

The standard rollers furnished handle mos shapes, especially since all rollers apply draw ing power. Shaped rollers, which apply gentl balanced draught to any deep or irregula shape, are available. Rollers are immediatel interchangeable.

The Plastimaster's two-speed motor, variabl speed drive and gear-reduction unit are all na tionally known for their high quality. Spec fications for these units and the entire ma chine are given in an illustrated brochur which we will be glad to send to you.

0″ to 5″ capacity
11.75 to 238 ft/min, roller surface
one-point roller adjustment
Fingertip speed control
Safety rollers
Geared head
Timken bearings



Write:

PLASTIMASTER

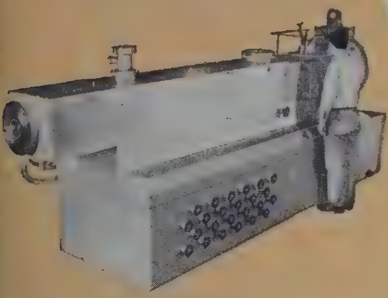
H & T MACHINE WORKS, INC.
11365 HUMBLE ROAD, HOUSTON 16, TEXAS

THE UNIQUE WEI DUAL WORM DESIGN GIVES

WELDING ENGINEERS COMPOUNDER-EXTRACTOR-EXTRUDERS

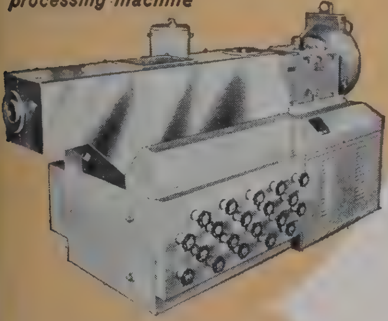
THE OPTIMUM IN PROCESSING ABILITY, FLEXIBILITY, OUTPUT

When you invest in WEI equipment you know in advance exactly what production you can count on: output and quality is pre-established by our research-engineering team. Problems inherent to your materials and your manufacturing processes are solved on custom-fitted dual worm equipment . . . labor-saving, space-saving, continuous all-in-one operation machines. In the whole range of thermoplastics . . . and rubber, as well . . . Welding Engineers compounding-extracting-extruding equipment continues as the most reliable in the service of America's foremost plastics and rubber manufacturers. Write for catalog No. 891.

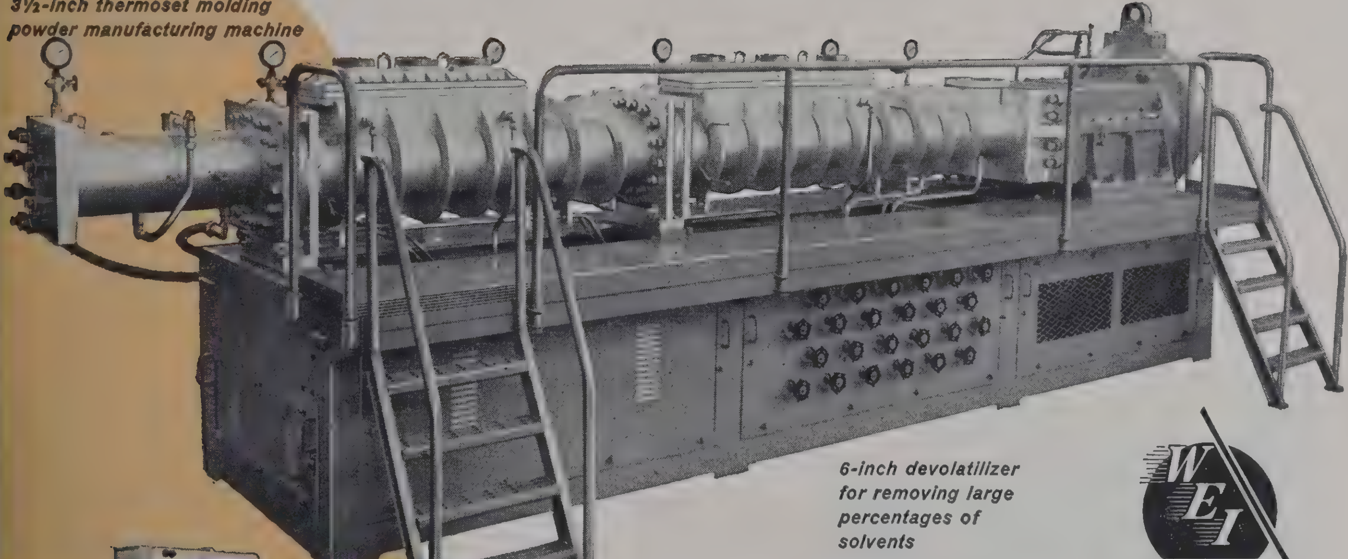


Typical 4½-inch low pressure polyethylene or polystyrene processing machine

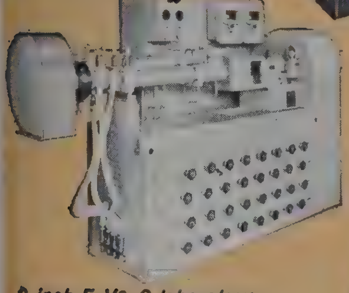
DESCRIPTIVE DATA	Series 2000	Series 2800	Series 3500	Series 4500	Series 6000
Dual Worms	each: 2″ dia.	each: 2.8″ dia.	each: 3.5″ dia.	each: 4.5″ dia.	each: 6.0″ dia.
Feed Inlet At Worms	3½″ dia.	5″ dia.	6″ dia.	8″ dia.	10″ dia.
Drive Motor For Standard Duty Machines	10 HP	25 HP	50 HP	100 HP	—
Drive Motor For Heavy Duty Machines	—	—	75 HP	150 HP	300 HP
Floor Space (Exclusive of Motor)	2′ x 7′	3′ x 8′	3′6″ x 10′	4′ x 14′	5′ x 20′



3½-inch thermoset molding powder manufacturing machine



6-inch devolatilizer for removing large percentages of solvents



2-inch F, V2, S laboratory experimental machine

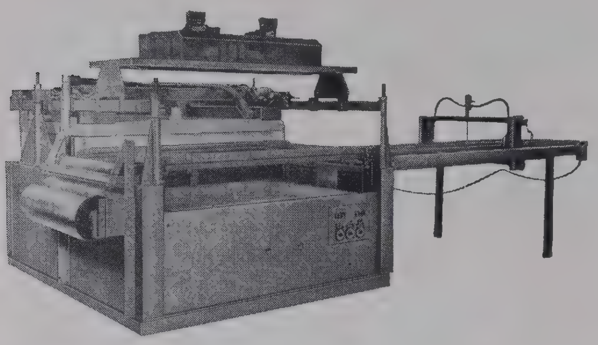
Welding Engineers, Inc.

NORRISTOWN, PENNSYLVANIA

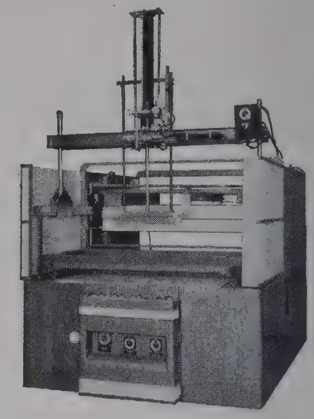
★ *West Coast Representatives—Machinery Sales Co.*
Los Angeles 58, California

★ *Exclusive Sales Representatives for Europe and the British Isles—Welding Engineers Ltd Geneva, Geneva, Switzerland*

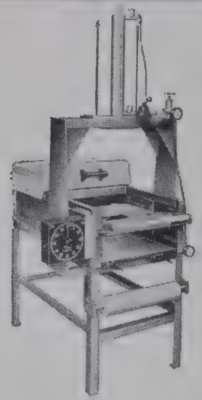
MASTER-VAC — large capacity — forming area 42" x 72"—product depth to 8"— Roll feed and semi-automatic take-off. Handles rolls of thermoplastic film and sheet materials up to 125 mil thickness. For high speed production of thin-gauge plastic articles or for forming large area heavy gauge items. Design and construction permits one-man operation from remote controls at take-off station.



MODEL EQA (shown with plug attachment) — "work-horse" of the industry. Easily adapted to skin packing and roll feed. Available in five standard models with forming areas 24" x 36", 30" x 50", 42" x 72", 50" x 50" and 48" x 72". Plug forming attachment increases versatility and permits deep-draw forming.



AUTO-VAC makes the



LAB-VAC — offers low-cost versatility for product and package design, material testing, prototype forming or short production packaging runs. Besides straight vacuum forming on female molds, drape forming on combination male and female molds, the Lab-Vac may be equipped for deep-draw, air cushion plug forming.

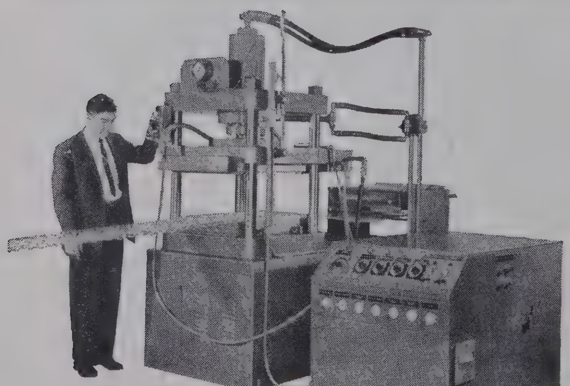
PRO-VAC — a vacuum forming production unit with 24" x 30" forming area automatic drape operation. Roll-feed, automatic heater travel, automatic clamping and plug forming attachments available. A medium size, low cost machine for production or "in between" jobs.

TWO-SIDED HEATING

MV-2 — Features heaters both above and below the plastic, each with independent drive, controls and timers to permit retraction of the lower heater at the exact moment of material sag. A completely versatile machine for straight vacuum, drape, plug/drape, snap back, "Air Slip," air cushioned plug and slipring forming. Designed for use with light and heavy gauge plastic sheet. Available in three forming areas — 30" x 50", 42" x 72" and 48" x 72", with drape and plug maximum depths to 16".

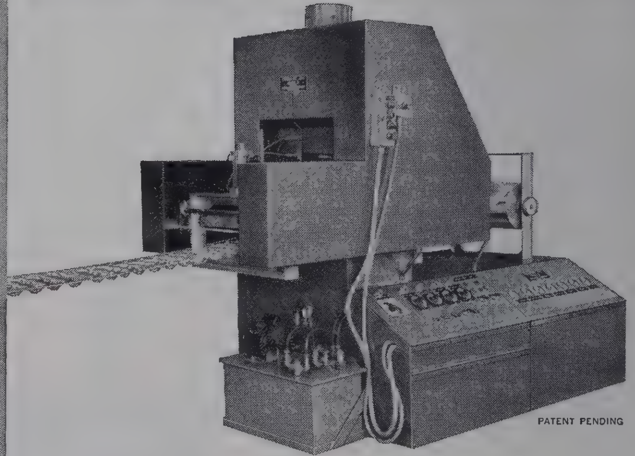
MV-2-24 — basically the MV-2 models with the addition of drape depths and plug attachments for forming items to 24" depth.

Photographs of the new MV-2 were not available at publication time, however these machines are now in production.



PATENT PENDING

PRESSURE-VAC ***Mark I*** — an extra-high production machine. Automatic operation permits forming up to 50 sq. ft. per min. Platen area 24" x 30" — forming area 23" x 29" — depths to 6". Either male or female molds may be used. Heater may be mounted above or below material for most efficient operation. Ideal for use in long run automated packaging or product forming lines. Forms any thermoplastic sheet or film from .001" to .125" thickness. Completely automatic or manual forming cycle with remote controls for operation at indexing or cutting stations. Automatic cutting and indexing accessories available.

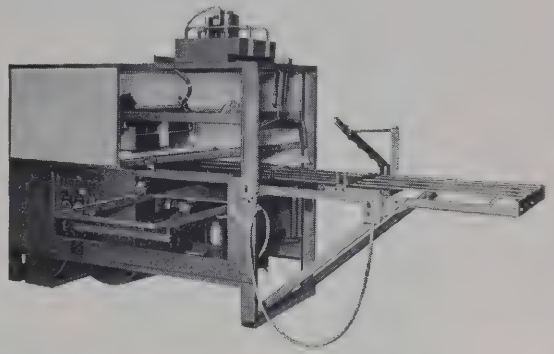


PATENT PENDING

PRESSURE-VAC ***Mark II*** — automatic operation — forms up to 30 sq. ft. per minute. Platen area 12" x 22"—forming area 11½" x 21½" —depth to 3". Forms any film from .001" to .025" in rolls, and sheets from .030" to .125". Male or female molds may be used. Heater may be positioned above or below material. Forming cycle is completely automatic or manual, with remote controls for operation from indexing or cutting stations. May be used in completely automated operations or in multi-purpose forming. Production changeover may be made in ½ hour. Automatic cutting and indexing accessories available.

MODEL L — largest production model vacuum forming machine in the world — used by television and movie production departments for forming props, scenery and flats. Ideal for general use in automotive, appliance, housing and transportation fields for forming items from 3" x 3" to 6 ft. x 12.6 ft., up to 24" deep, with excellent detail and high definition.

AUTO-PAK — for unusually high volume production in skin packing, blister packing and the Auto-Vac "Snap-Pak" process. Simultaneous manual indexing and sheet cutting. Designed for quick mold changes—switch rapidly and easily from one process to another. Has roll feed and 20" x 25" forming area. Plug attachment accessory permits forming deep draw items to 5" depth with heavier corners, edges and more uniform wall and bottom thickness.



most complete line . . .

There's an AUTO-VAC for ANY thermoforming job

Auto-Vac, pioneer producer of machines for thermoforming plastic sheet and film, has an outstanding record in the development of thermoforming machines and most of the forming techniques currently in use in such varied fields as packaging, appliances, furniture, automotive, toys, housing, transportation and displays.

This experience, plus the best in design, engineering and materials, is available to you in every Auto-Vac machine. The complete line of machines offered by Auto-Vac includes an efficient model and size for every kind of thermoforming of all plastic sheet or film for products from ¼ inch diameter to 6 feet x 12 feet.

PRESSURE FORMING - New high production machines

For exceptionally fast, low cost production of any thermoplastic film or sheet with high detail and extremely close tolerances. Pressure forming is ideal for low cost individual portion servers; transparent packages for tomatoes, fruits, baked goods, meats, including fowl; snap on lids, display packages, trademarks, embossed panels, etc. Direct contact heating plus high pressures permits forming all sheet thermoplastic material, including oriented styrene, Mylar®, Nylon®, cast acrylic, PVC, etc. Forming cycles are 4 times faster than conventional vacuum or drape forming.

®DuPont trademarks

AUTO-VAC machines may be obtained by:

- LEASE-RENTAL PLAN
- TIME PAYMENT PLAN
- OUTRIGHT PURCHASE

Complete information on request.

For complete information on any Auto-Vac machine write or call:

AUTO-VAC Company
A DIVISION OF NATIONAL CLEVELAND CORPORATION
727 Railroad Avenue, Bridgeport 5, Connecticut
EDison 4-9481 • TWX – 568

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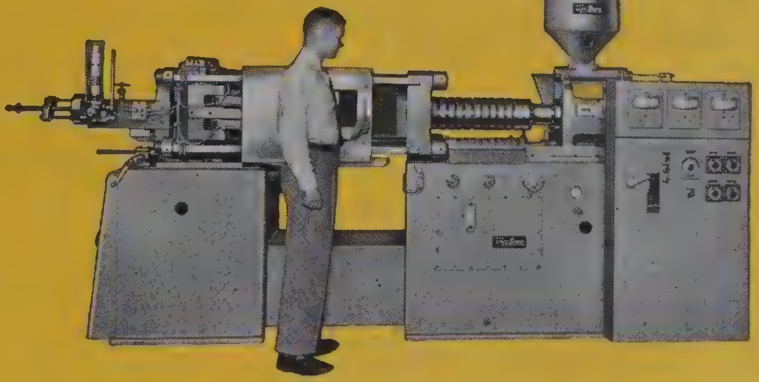
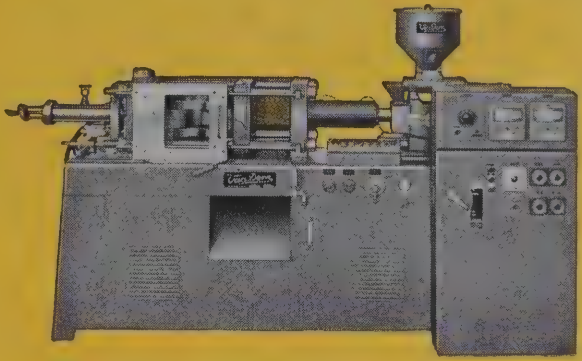
Produce Plastics Profitably!

Model H-400
4-6 oz. CAPACITY

This automatic Van Dorn plasticizes 100 pounds plus per hour, has 175 tons clamping pressure, and achieves up to 840 dry cycles per hour. This press also features: Fast Mold Set Up, Four Tie Bars, Adjustable Toggle Stroke, and Maximum Operator Protection.



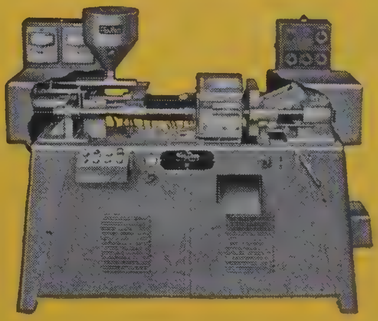
SELECT A VAN DORN PRESS



Model H-300 3 oz. CAPACITY

This automatic Van Dorn plasticizes 65 pounds plus per hour, has 75 tons clamping pressure, and achieves up to 1200 dry cycles per hour. This press also features: Fast Mold Set Up, Four Tie Bars, Adjustable Toggle Stroke, and Maximum Operator Protection.

BEST FOR YOUR NEEDS



Model H-260 2½ oz. CAPACITY

For greater efficiency, this automatic Van Dorn has a High Capacity Heater. The press plasticizes 30 lbs. plus per hour, has 30 tons clamping pressure, and achieves up to 720 dry cycles per hour. This press also features a Fast Mold Set Up.

Write for Detailed Information

The Van Dorn Line also includes 2 oz. and 1 oz. capacity presses, and scrap granulators.

THE VAN DORN IRON WORKS CO.
2685 East 79th Street • Cleveland 4, Ohio

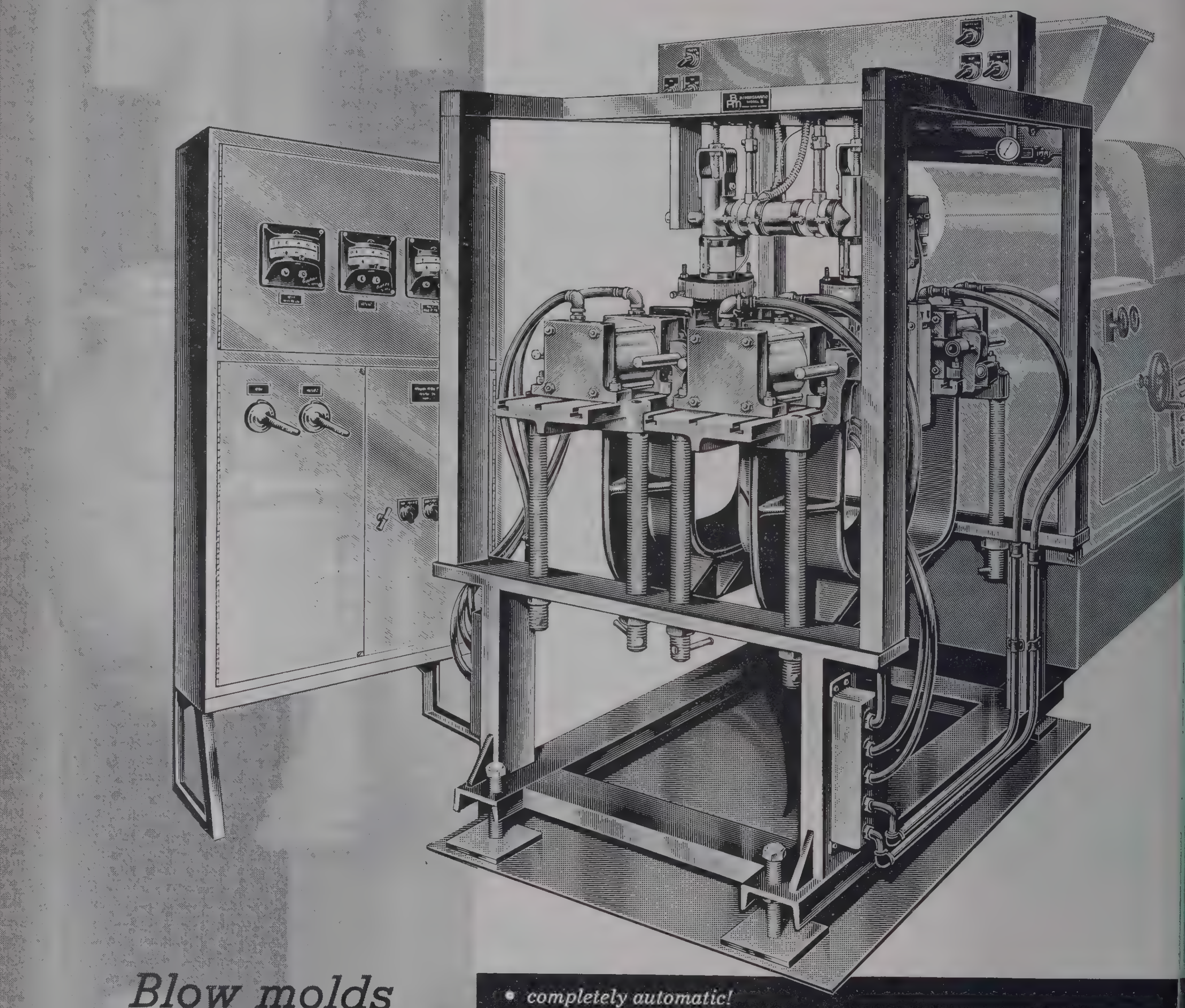
Van Dorn
Established 1872

Now . . . the finest, fastest, most versatile blow molder ever developed . . . the American made . . .

DIVERSAMATIC MODEL B

Twin Head Blow Molding Machine

(MADE IN U.S.A. PAT. PENDING)



Blow molds an unlimited variety of hollow items

- *completely automatic!*
- *super-size capacity — takes molds up to 36" long, 14" wide, 21" daylight — finished items 1" to 34" in length!*
- *super-range versatility — operates with identical or different molds at same time. Either or both molds may be single cavity or vertically-strung multiple cavity. Produces parisons from ½" to 4" O.D.!*
- *manual controls for fast set-ups and test runs!*
- *operates with any extruder — domestic or foreign!*
- *all pneumatic system — no leaks, no mess — faster, cleaner and more efficient!*
- *low operation and maintenance costs — replacement parts easily obtainable!*

The Diversamatic is now in profitable operation in various industries throughout the country. To learn how your company can profit, contact us for a demonstration or send for free booklet.
Write, wire or phone . . .

BOSTON PLASTIC MACHINERY INC.
215 A Street, Boston 10, Massachusetts, Telephone: ANdrew 8-4600

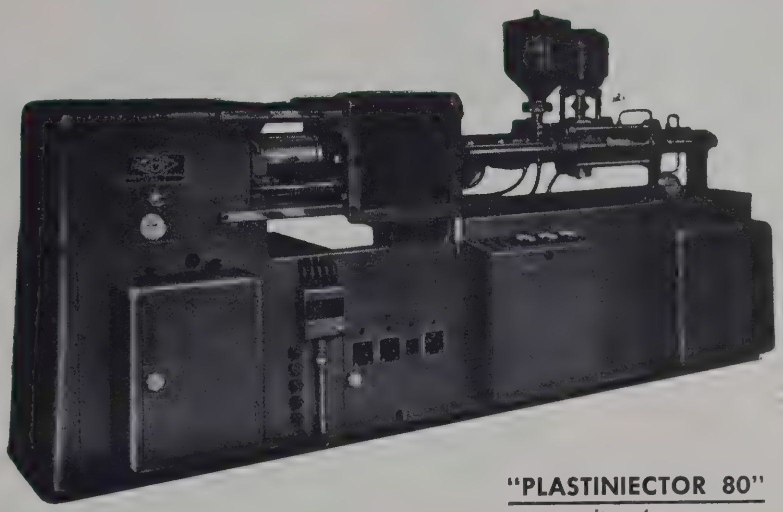
NEW DEVELOPMENT

DYNAMIC PREPLASTICIZER
FAST INJECTION SPEED

G. B. F. "PLASTINIECTOR"

world patent

moulds better
moulds faster
self-contained
fully automatic
oil hydraulic



"PLASTINIECTOR 80"
capacity: 4 oz.
7 c. inch

Other sizes available:
2- 6- 11 and 18-oz.

ADVANTAGES:

1. Uniform plasticizing and high injection rate at lower temperature.
2. Total pressure directly on the material.
3. Extremely fast injection.
4. Exact weight of each shot due to the volumetric injection of the preplasticized material.
5. Low injection pressure.
6. No change of container for the various materials and colours.
7. Automatic operation cycle regulable by timers and continuously controlled.
8. Parts better in quality and uniform in size, also on large areas and on thin walled sections.
9. Hourly plasticizing capacity:

2 oz.	4 oz.	6 oz.	11 oz.	18 oz.
20 lbs.	30 lbs.	49 lbs.	88 lbs.	145 lbs.

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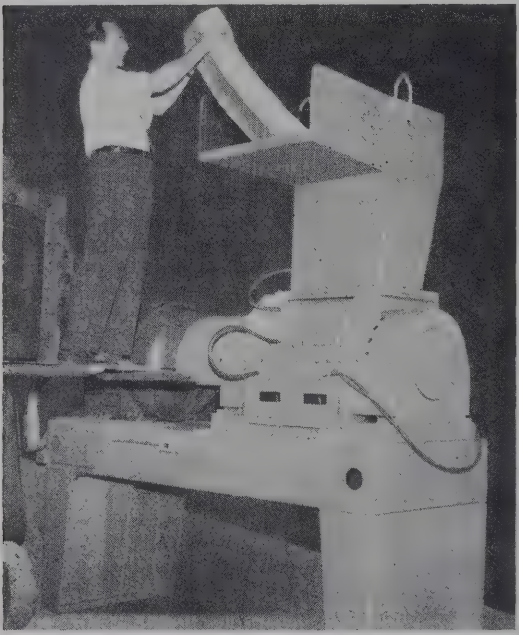
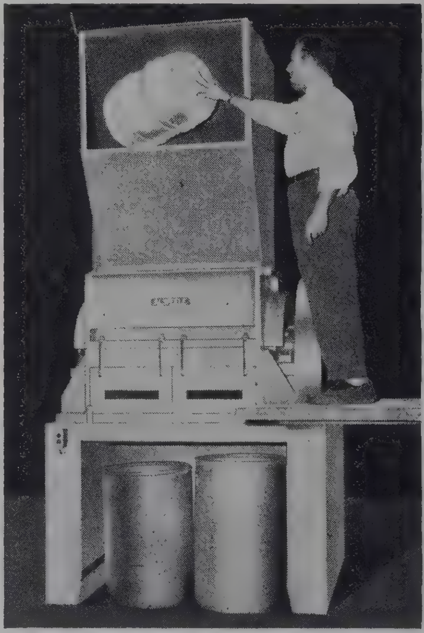
You couldn't ask for better "workers" than . . .

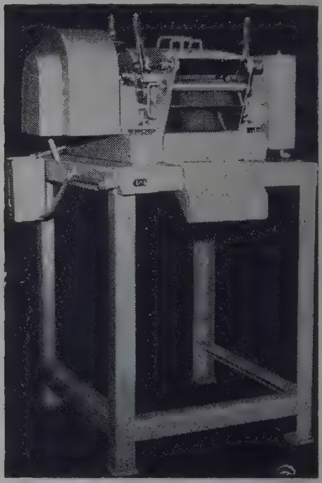
ALSTEELE *Granulators and Pelletizers*



Alsteele Granulator: 100-150-200 HP



Alsteele Granulator, Model 24 x 36, for grinding very large molded parts without prior cutting. Several models in this series can granulate entire refrigerated door liners. Available in sizes 12 x 24", 12 x 36", 12 x 48", 12 x 60", 24 x 36", or larger.



Hi-Speed Pelletizers to handle entire extruder output

Versatile Alsteele Granulators

Alsteele Granulators handle the entire range of thermoplastics, whether the material be .001" film or 11"-thick chunk solids. Even the largest molded objects require no prior sawing. And Alsteele Granulators cut polyethylene and vinyl so the bulk factor will approximate your virgin material.

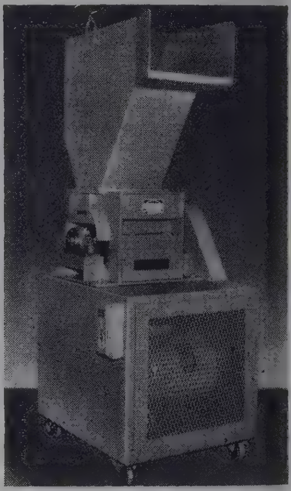
For extra durability, the Granulator cutting chambers are *all steel* . . . for extra strength, the hardened forged rotor is machined from *all steel* . . . and for smooth, constant cutting the two large heavy duty flywheels are *all steel.* Heavy duty machines are *water cooled.*

To meet your every need in plastics reducing machinery—whether for beside-the-press operation or for heavy duty chunk grinders—Alsteele Granulators come in 26 models ranging in size from 3 HP to 200 HP, with cutting chambers up to 5'.

Precision Alsteele Pelletizers

The Alsteele line of pelletizers works with extruders 2½" to 6" or larger. Instant synchronization with an extruder is made possible by the U.S. Varidrive. And ease of operation, maintenance and cleaning is insured by extremely compact design.

Additional features are excellent uniformity of pellets, and clean cutting action—even on elastomerics. A greatly lowered noise level is still another benefit.



Beside-the-Press Granulators in a complete range of sizes

Call or write our office nearest you for full price, performance and specification data.

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Alsteele 5 x 10"
Heavy Duty,
Water-Cooled Chunk Grinder

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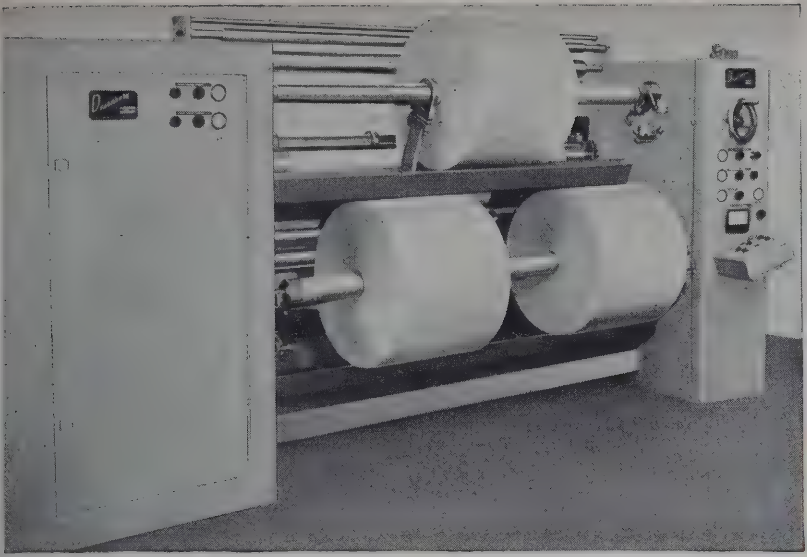
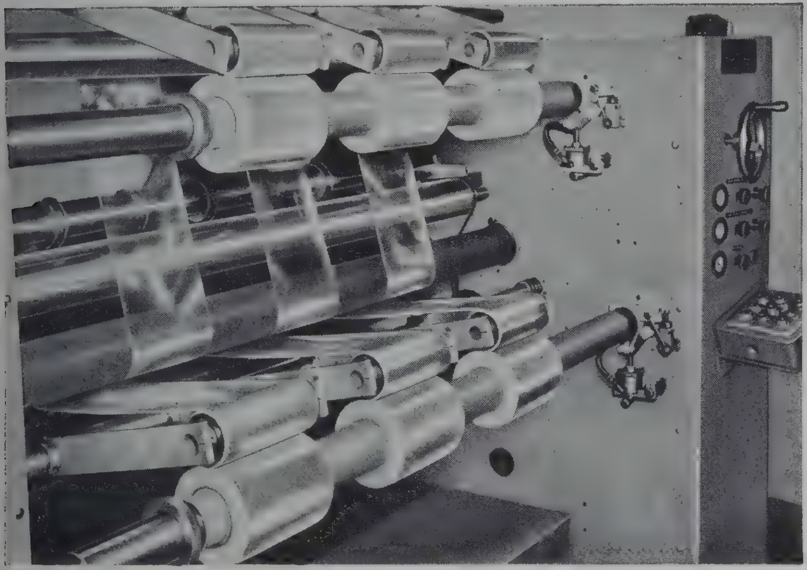




DUSENBERY
MODEL 815
HIGH SPEED
SLITTER
AND
REWINDER

SHEAR CUT,
RAZOR BLADE
AND/OR SCORE CUT

For Paper, Tape,
All Plastic Films,
Foils and
Laminates

Versatile...

Handles light gauge
S-T-R-E-T-C-H-Y
materials and heavier
weight paper with
equal facility.

The Model 815 employs the differential rewind principle. High quality rewind rolls are produced despite out of caliper mill rolls and materials by allowing each rewound roll to slip with respect to its neighboring rolls and be wound up under its own tension control. The differential rewind reduces rejects, resulting in more economical production.

For high speed running, the rewind mandrel speed is automatically reduced to prevent overheating or burning of the cores due to excess slipping between the core and the driving spacer or mandrel. In this way maximum speed of 1500 FPM may be achieved.

Complete information upon request

Dusenbery

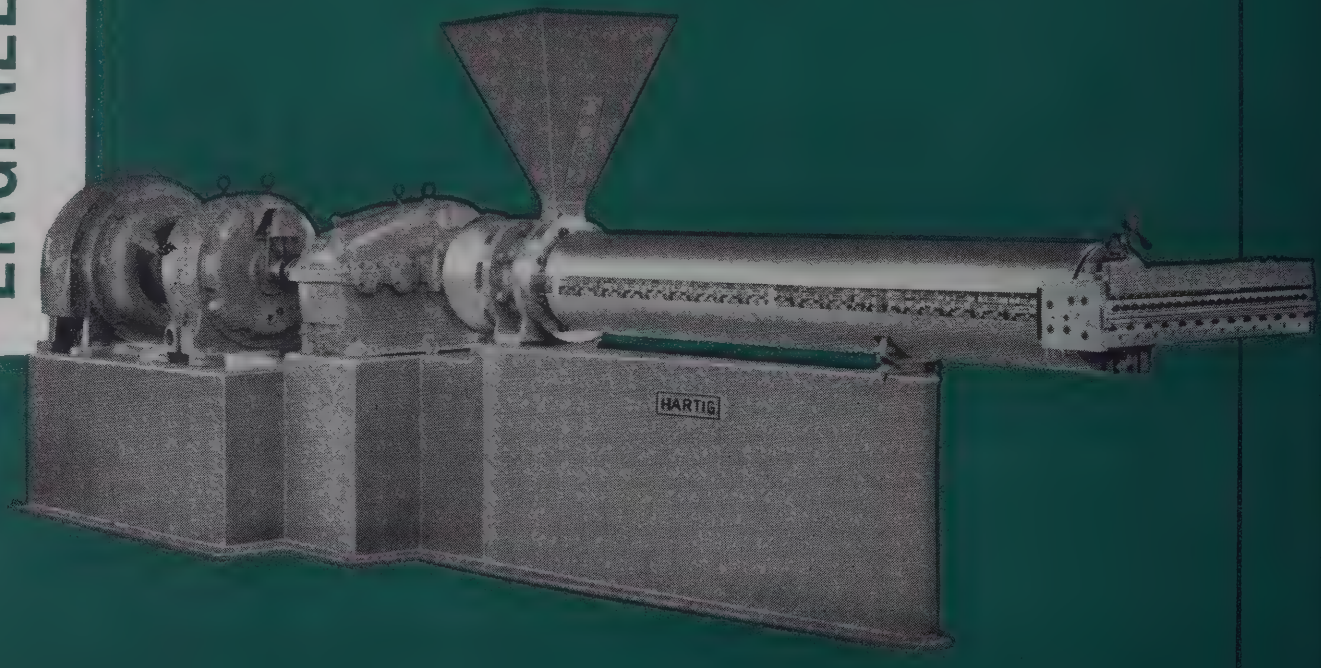
JOHN DUSENBERY CO., INC.
274 GROVE AVE., VERONA, N. J.

ENGINEERED
CONVERTING
EQUIPMENT

ENGINEERED INSTALLATIONS

HARTIG extruders and matched auxiliary equipment

Hartig 4½" Extra Long Extruder, 24:1 L/D with sheeting die



for

- Sheet Extrusion — Vacuum Forming
- Film Extrusion — Blown Tubing, Unsupported Film, Laminating
- Wire and Cable — Insulation and Sheaths
- Pipe, Tubing, Rod and Profile Extrusion
- Blown Containers — Molding
- Compounding — Reprocessing

The 130 years of experience of the John Waldron Corporation is also available for complete process engineered installations.

materials now being processed on Hartig Extruders

- Nylon
- Polystyrene
- Cellulose Acetate
- Cellulose Acetate-Butyrate
- Acrylic Resins
- Vinylidene Chloride
- Polypropylene
- Rubber
- Fluorothene
- Polyvinyl Chloride
- Casein
- Polyvinyl Butyrate
- Ethyl Cellulose
- Polyethylene

extruder specifications

sizes	1½″ to 12″
capacities	15 lbs/hr to 3000 lbs/hr depending on the nature of the job.
L/D ratios	15:1, 21:1, 24:1, and 30:1.
drive	Variable speed motor. Herringbone gear reducers.
thrust bearing	Spherical roller bearing for radial loads, and self aligning spherical roller bearing for thrust loads—completely enclosed and force lubricated.
feed	Fabricated throat section with provision for water cooling.
cylinder	Steel barrel with centrifugally cast Xaloy liner.
screw	Alloy or stainless steel with hard-surfaced or flame-hardened flights. Constant pitch, decreasing depth, or variable pitch. Devolatizing and recirculating types available.
closure	Heavy duty clamp type, quick opening
temperature controls	Heated by means of band heaters, or extruded, or cast-in-aluminum calrod units. Controls are proportioning type or stepless (saturable core reactors). Controlled by air or water or both along entire length of barrel.
venting and devolatilizing	Special screw construction for elimination of volatiles, optional.

auxiliary equipment

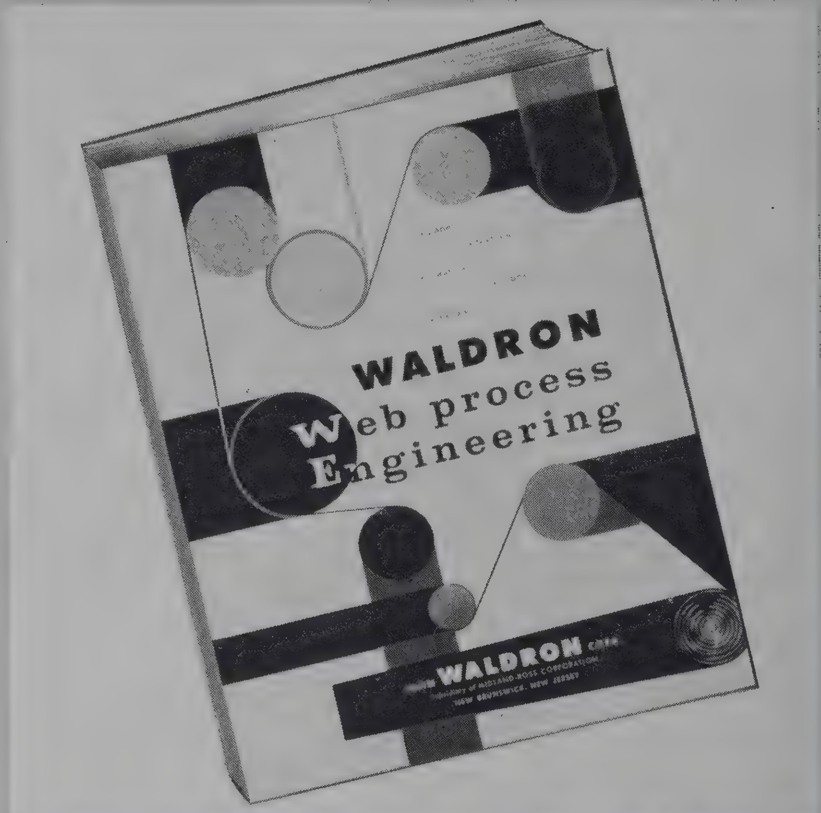
dies	Film or laminating dies for widths up to 120″. Blown tubing dies up to 48″ diameter, and for lay-flat tubing up to 144″. Pipe dies, profile dies. Sizing and cooling dies. Adjustable centering crossheads. Special purpose dies.
payoffs, takeoffs troughs	Film takeup units—for widths to 120″. Blown tubing takeup units with collapsing roll assembly. Constant tension. Also available for lay-flat tubing up to 144″. Pipe pulloff units. Water troughs. Capstans. Dual reel high speed continuous takeup with adjustable traverse. Constant tension, counter. High speed payoff stand with automatic brakes and dancer for tension control. Conveyors with counterbalanced pressure roll.
processing equipment	Cooling and polishing rolls. Laminators for web widths to 120″ with unwind and rewind stations. Pelletizers.
special purpose auxiliary equipment	Hartig engineers have designed, built, and installed extruders and auxiliary equipment for specific production tasks. In doing so, they may already have solved your problem.

Send for your copy of
the new booklet
describing the complete
line of Hartig Extruders
and Auxiliary Equipment.

M-R
MIDLAND · ROSS CORP.

HARTIG
EXTRUDERS

Established 1890
Division of Midland-Ross Corporation
Mountainside, New Jersey


WALDRON
Web process
Engineering
WALDRON
Subsidiary of MIDLAND-ROSS CORPORATION
NEW BRUNSWICK, NEW JERSEY

WEB PROCESSING

A study of this 130 page, well-illustrated catalog will disclose three features of Waldron Service, features that mean much to the purchaser:

❶ exceptionally broad experience in the field of web processing.

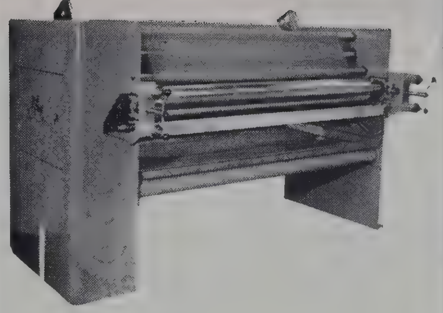
❷ practically every machine ordered is individually designed; Waldron machines are custom built.

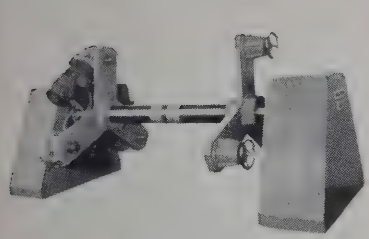
❸ auxiliary equipment also is Waldron design.

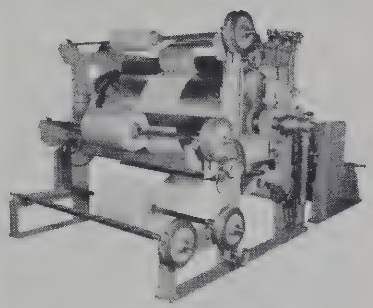
And these three features are largely responsible for the thousands of successful web-processing installations carrying the nameplate 'Waldron.'

Waldron Engineers, in designing the equipment, take into consideration every factor involved. Since seldom are any two projects alike, it means that each design job has its distinctive variations. The processing of a *plastic* web is not an easy job under the simplest of requirements. And each new plastic material, as it comes on the market, calls for a new evaluation of all factors. To all such problems Waldron Engineers bring just about the broadest experience available, certainly the oldest experience.

We suggest that you send for our General Catalog No. 10. If you have plans for processing webs of any kind, why not discuss them with one of our experienced Web Processing Engineers?

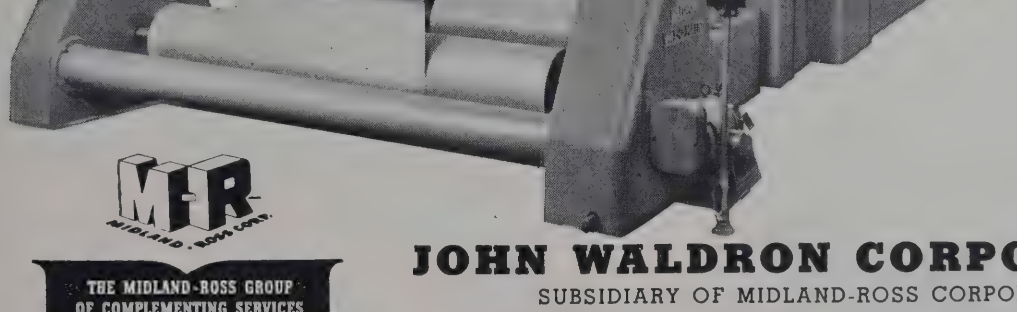






MACHINERY FOR PLASTICS

by Engineers Widely Experienced in Processing All Kinds of Webs



M-R MIDLAND-ROSS CORP.

THE MIDLAND-ROSS GROUP OF COMPLEMENTING SERVICES

J. O. Ross Engineering, New York
John Waldron Corporation, New Brunswick, N. J.
Andrews and Goodrich, Boston
Ross Engineering of Canada Limited, Montreal
Ross Midwest Fulton, Dayton
Hartig Extruders, Mountainside, N. J.
Carrier-Ross Engineering Company, Ltd., England

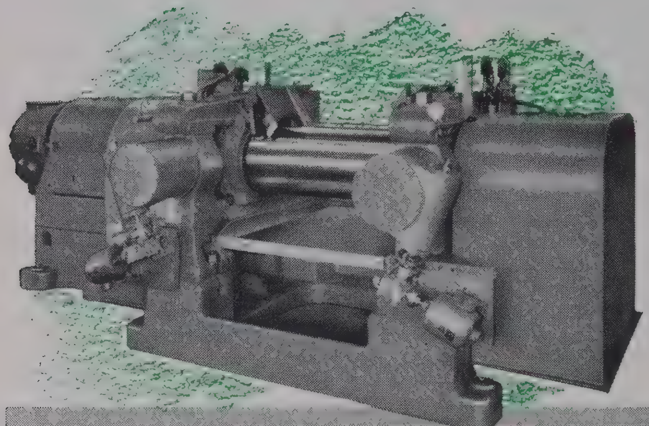
JOHN WALDRON CORPORATION

SUBSIDIARY OF MIDLAND-ROSS CORPORATION

LEADER IN WEB PROCESS ENGINEERING SINCE 1827
NEW BRUNSWICK, NEW JERSEY • MT. PROSPECT, ILL. • LOS ANGELES
WEST COAST REPRESENTATIVE: BOJANOWER MACHINERY SERVICE CO.
5270 EAST WASHINGTON BOULEVARD, LOS ANGELES 22, CALIFORNIA

ADAMSON UNITED

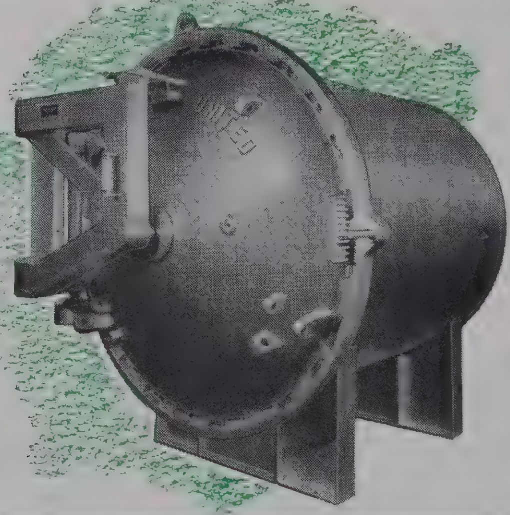
RUBBER AND



MILLS, REFINERS, CRACKERS, WASHERS

Mills are built in all standard sizes as well as special sizes to meet specific requirements. The mill illustrated has rolls 20" in diameter, 48" long. The motor drive is direct-connected to the rear roll. It also has motor-operated adjusting screws, flood lubrication, front roll position indicators, tilting stock guides, two sets of connecting gears for operating at two different friction ratios.

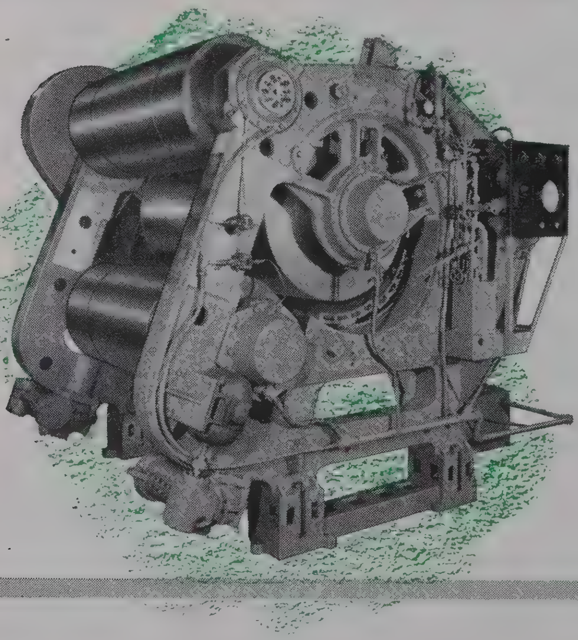
Mills can be supplied driven individually, in pairs, or in groups on a line shaft and may be floor mounted on vibration mounts if desired. In addition to all types of standard mills, refiners, crackers, and washers, we design and build special-purpose units for new rubber and plastics processes.



AUTOCLAVES, VULCANIZERS, POT HEATERS

Adamson United offers a full line of horizontal and vertical pressure vessels in diameters from 12" to 15′ and any length. They can be built for full vacuum or internal pressures up to 2500 psi. A variety of quick-opening, positive-locking door arrangements are available including breech-lock davit or hinge-type, slide-lock, third-ring type, and others. Vessels can be single shell or jacketed and may be equipped with internal coils, circulating fans and automatic controls for programed process control.

The 72" I.D. horizontal vulcanizer shown has a breech-lock, hinge-type door.



ROTOCURES*

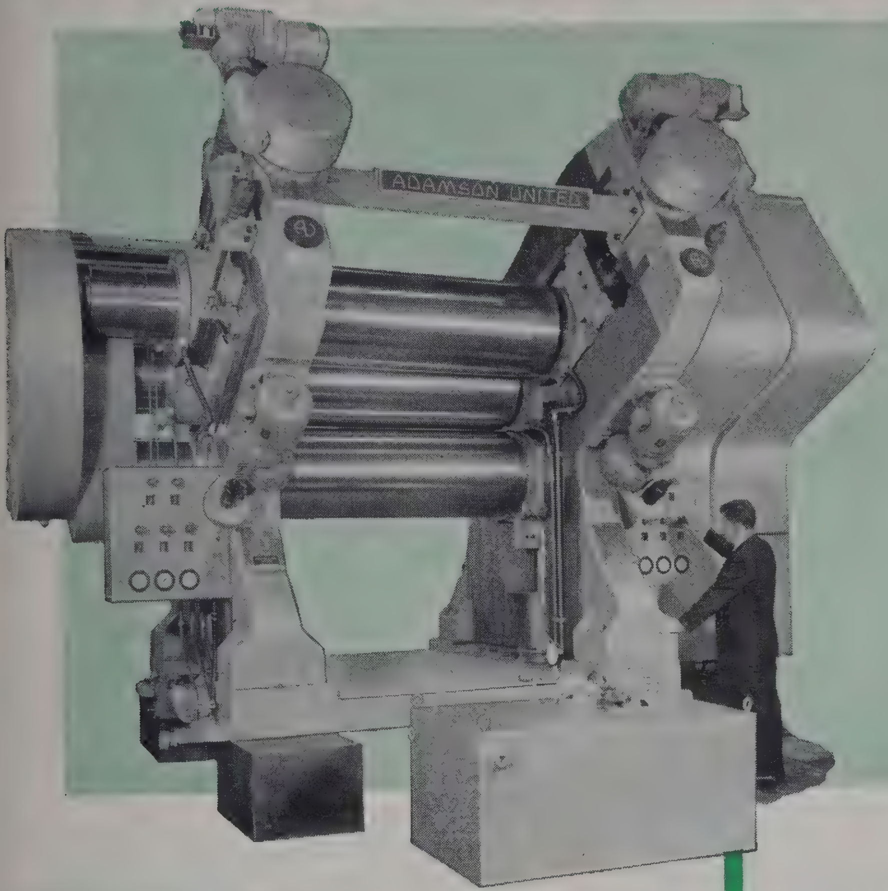
The standard Rotocure illustrated has a vulcanizing roll 60" in diameter, 80" long. Curing speed is adjustable from 0.5 to 8.0 fpm. Maximum belt tension is 240,000 lbs.

Available with either steam or electric heating, the Rotocure provides continuous curing of standard belting, flooring, or sheeting, as well as rubber or plastic articles with molded pattern surfaces. It gives a uniform cure with no overcuring or undercuring of over-lap areas as occurs on conventional equipment, and eliminates time and heat losses due to opening and closing. Roll and belt changes are made quickly and easily. An additional pressure roll can be provided for molding deeper patterns and increased production rate.

**Patented by Boston Woven Hose and Rubber Co. Built by Adamson United Co. under a licensing arrangement.*

- DESIGNERS AND BUILDERS OF BASIC AND SPECIAL MACHINERY FOR THE RUBBER, PLASTICS AND PLYWOOD INDUSTRIES

PLASTICS PROCESSING MACHINERY



CALENDERS

We offer a complete line of calenders designed to meet modern production requirements for speed and precision. Sizes range from 8″ x 16″ laboratory models to large production units with rolls measuring 36″ x 92″. They may be equipped with such features as roll bending, roll crossing, drilled rolls, anti-friction bearings, and pinion-stand drive. Calender types include 2- and 3-roll vertical, inverted-L, Z-type, cascade, inclined, and others.

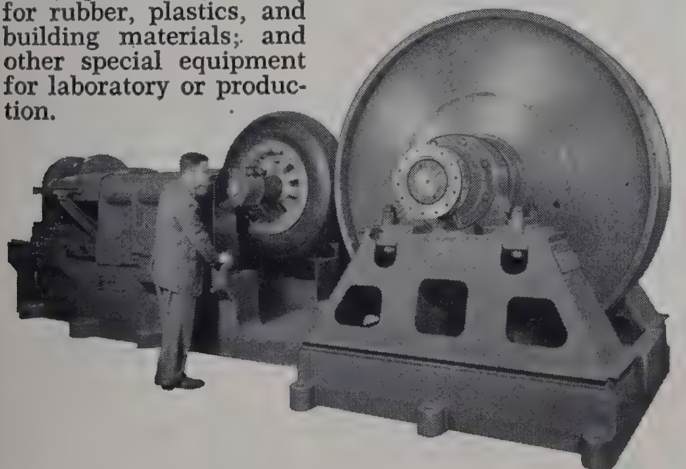
Shown is a 24″ x 68″, 3-roll, 120 degree, connecting gear-type calender with roll crossing.

A full line of accessory equipment for continuous processing is also available. This includes equipment for production of rubber and plastic sheeting, and for fabric coating operations.

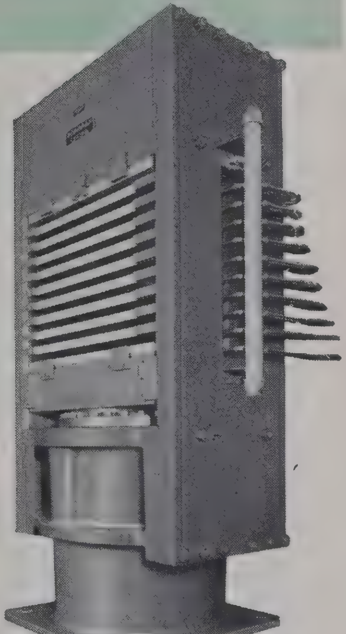
SPECIAL MACHINERY

Shown is the 80,000-lb. load side of an Adamson-built aircraft tire and brake tester. The inertia wheel is 120″ in diameter, develops speed of 300 mph.

We also design and build special presses for plywood, hardboard and decorative laminates; synthetic rubber baling presses; continuous chipboard extrusion machinery; ram-type vulcanizers for large off-the-road tires; special large molds for rubber, plastics, and building materials; and other special equipment for laboratory or production.



HYDRAULIC PRESSES



The 64″ x 42″ side-plate type press shown is designed for compression molding requiring extremely low deflection. Other standard types available are four-column, window frame, gooseneck, and barrel-type hydraulic presses. Standard sizes of square presses range from 12″ x 12″ to 76″ x 76″; rectangular platen presses in lengths to 31′.

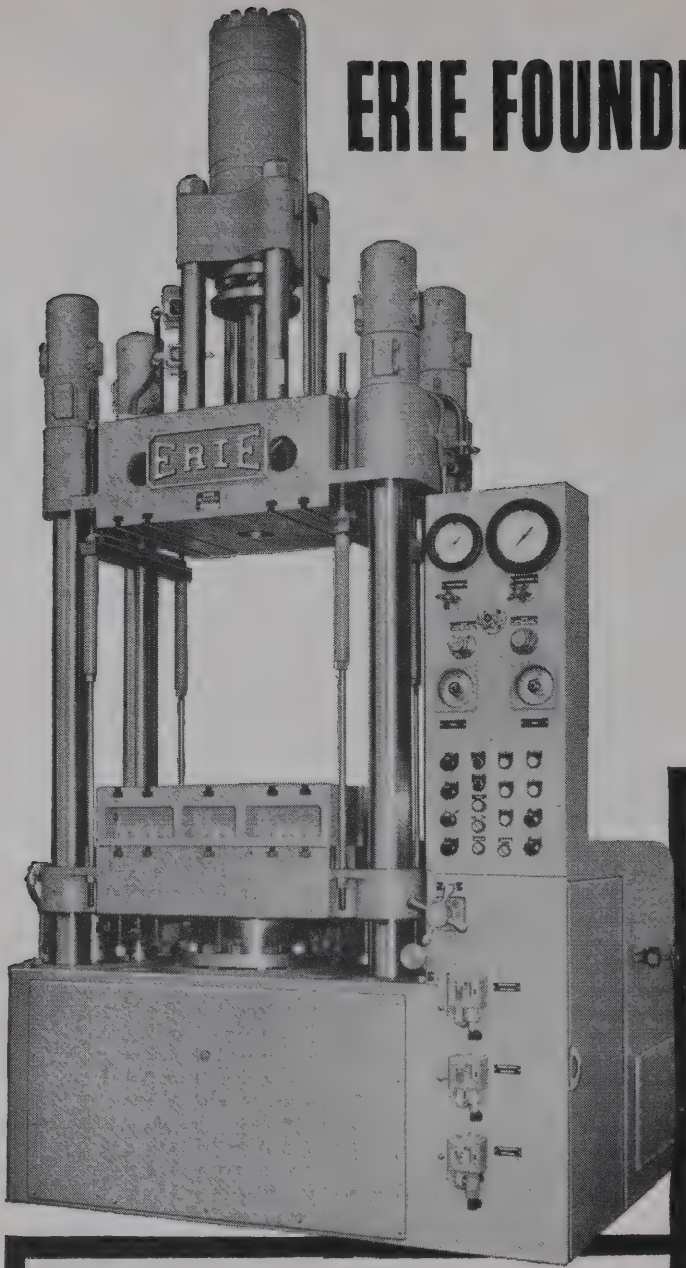
Our standard presses include types for compression, transfer, and injection molding of rubber and plastics, as well as presses for V-belts, flat belting, laboratory use, and automatic molding of multiple parts. We are also equipped to design and build special units to meet specific requirements.

ADAMSON UNITED
COMPANY

730 CARROLL STREET, AKRON 4, OHIO

Subsidiary of United Engineering and Foundry Company
Plants at Pittsburgh, Vandergrift, Wilmington, Youngstown, Canton

7075

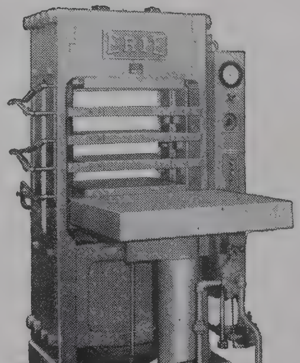


ERIE FOUNDRY HYDRAULIC PRESSES for MOLDING RUBBER and PLASTICS

Hydraulic presses, designed and built by Erie Foundry Company are precision presses in every sense of the word . . . tonnages are accurate and precisely applied, platen temperatures are closely controlled, and molding cycles perform at split second timing. Erie Foundry Hydraulic Presses are flexible too . . . readily adaptable to almost any molding job. Write for complete information on these presses or on the complete line of Erie Foundry rubber and plastic hydraulic presses.

TRANSFER and COMPRESSION MOLDING PRESS

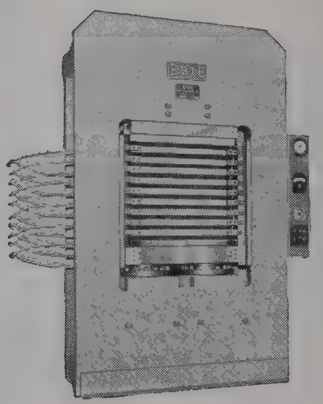
A flexible press for both compression and transfer molding is this 200 ton self-contained semi-automatic Erie press. This machine is equipped with a 55 ton transfer cylinder which can be timed separately from the main ram, as well as knock out cylinders on the bolster and a mechanical knock out for the top mold. Automatic cycling can be easily arranged to mold almost any product.



STRAIN PLATE PRESS for MINIMUM DEFLECTION

The platens stay parallel within .002" on this 314 ton press built of low-stress construction throughout. This press can be converted to transfer molding if desired.

We built the hydraulic lift table, too.



HOT PLATEN PRESS OF ECONOMICAL DESIGN

This 800 ton press is compact and rigid. Accurate platen alignment is maintained with minimum deflection over entire range of platen temperatures.

ERIE

Hydraulic Press Division

ERIE FOUNDRY CO. ERIE 9, PA.

SINCE 1895 THE GREATEST NAME IN HYDRAULIC PRESSES

CONTROL THE ROLL

from unwind to rewind

AND YOU CONTROL COST, QUALITY, AND PRODUCTIVITY IN SLITTING, REWINDING AND WEB-FED CONVERTING

Complete automatic roll control, perfectly integrated from unwind to rewind, is rapidly becoming an absolute essential in all areas of slitting, rewinding, web-fed printing and web-fed processing. Today's high-speed, high-volume production systems cannot tolerate the weaknesses inherent in a piecemeal roll handling arrangement.

There are literally hundreds of possible combinations of of tension sensing systems, unwind brakes, edge guides and other web control devices. The problem is to make them work together for integrated roll control. For example, a good tension sensing system is of little value unless its responses actuate a properly fitted brake of the right design and capacity. Sensing and braking are useless if edge guides fail to respond or if the rewind method employed does not suit the material.

To provide equipment that will work in perfect unison to keep a fast-running web under precision control all the way from unwind to rewind is a job for roll handling specialists-engineers who are thoroughly experienced in every phase of the entire unwind-to-rewind process.

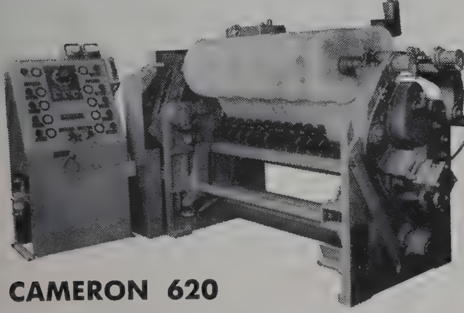
HERE IS ONE *SURE* WAY TO GET INTEGRATED AUTOMATIC ROLL CONTROL

Recognizing the growing need for completely integrated automatic roll control Cameron Specialists have established a unique Testing and Development Department. This department is completely equipped for engineered test runs on all types of flexible web materials. Various unwind, rewind, slitting and control elements are teamed to achieve optimum efficiency. You are invited to consult with Cameron Specialists regarding free test runs on your material. Let Cameron help you *stay ahead!* Write or telephone, now.

Cameron Machine Company, Franklin Road, Dover, N. J.
Canada: Cameron Machine Co. of Canada, Ltd., 15 Hatt St., Dundas, Ontario
France: Batignolles-Chatillon, 5 Rue De Monttessuy, Paris (7e) France

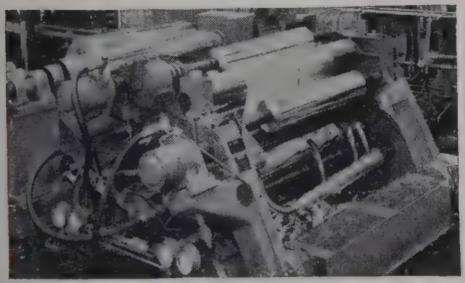
CAMERON
a Team of Specialists

TWO NEW MACHINES FROM CAMERON'S FAMOUS LINE OF SLITTER-REWINDERS



CAMERON 620

Versatile! High-Speed! A general purpose slitter-rewinder widely used in processing off-caliper materials, including paper, plastics, foils and laminates. 620 is a popular member of the famous Cameron line of slitters, roll winders, unwinds and web control systems.

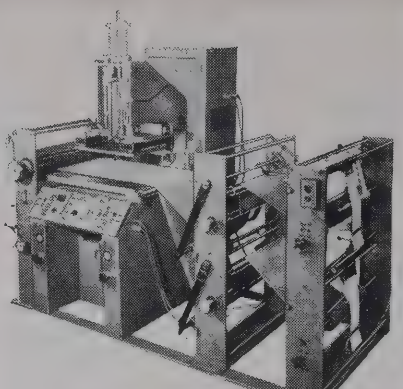


CAMERON 650

A fast, rugged Cameron built to meet special requirements. It is used for separating, slitting and rewinding two-ply foil. 650 is shown processing a "double" web of .00035 foil. Speeds up to 2000 fpm. Rewind diameter up to 30". Widths to suit requirements. Can use score-cut, shear-cut, burst-cut or razor-cut slitting.

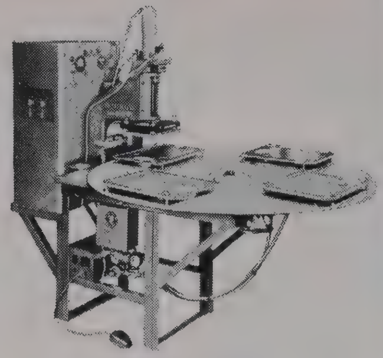
ASK ABOUT THE CAMERON LEASE PLAN. A LOW, LOW INVESTMENT PUTS PROFIT-BUILDING NEW EQUIPMENT TO WORK FOR YOU RIGHT AWAY.

53 years devoted exclusively to the design and manufacture of slitting, roll winding, unwind and web control equipment.



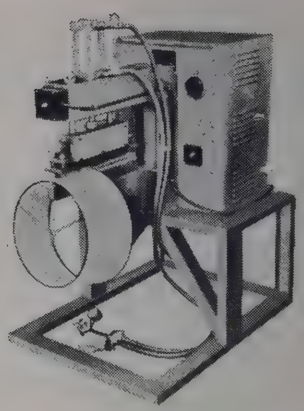
AUTOMATIC INDEXER

Sealomatic Indexer feeds, indexes, seals and rewinds vinyl sheeting without an operator. The entire operation is completely automatic and eliminates manual labor. Sealomatic Indexer is available with any size press or can be fitted to your present equipment.



TURNTABLE UNITS FOR AUTOMATION

For speed and flexibility, an automatic turntable unit is available with all Sealomatic sealers in 46," 60" and 72" diameters, adjustable for 4, 6, 8, 12 and 24 stops per revolution. Turntable units can also be fitted to your present equipment. Data Sheet T.T.



FOR SPECIAL APPLICATIONS

Units for lampshade sealing, applique work and three-dimensional sealing and many other individual specifications available and built to order.

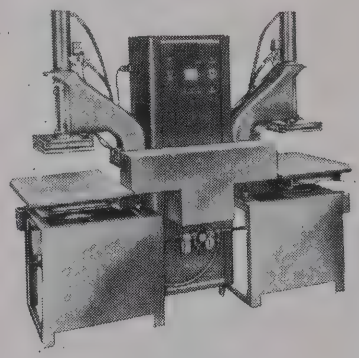
SEALOMATIC

ELECTRONIC

HEAT SEALING MACHINES

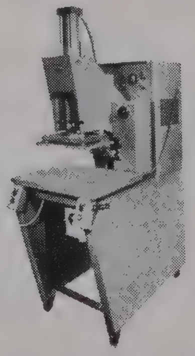
DUAL UNITS FOR FLEXIBILITY OF OPERATION

Here is a major step forward in economy of operation—one generator with two presses . . . minmum investment in equipment, yet extra production when you want it. Ask for Data Sheet D.U.



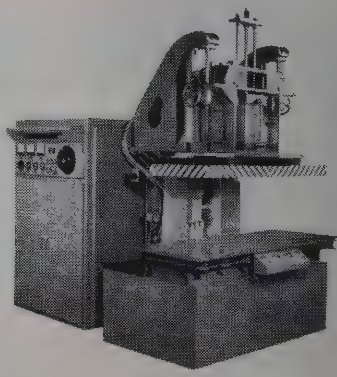
FOR EVERY POWER REQUIREMENT

Sealomatic standard models are available in capacities from ½ KW up to 30 KW to weld, cut, or emboss flexible, rigid, and foam plastic products. Our engineers will analyze your sealing problem and recommend the unit that best meets your needs.



HEAVY-DUTY 30KW UNIT

Especially designed for large, difficult seals such as inflatable mattresses, garment bags and upholstery fabrics. Sealomatic 30kw units eliminate several, separate sealing steps.



SEALOMATIC ELECTRONICS CORPORATION

429 KENT AVE.
BROOKLYN 11, N. Y.
EVERGREEN 8-9413

1362 JEAN TALON ST. EAST
MONTREAL 35, P.Q., CANADA
CRESCENT 4-8274

REPRESENTATIVES IN ALL MAJOR CITIES AND MEXICO

CUSTOM BUILT UNITS TO YOUR SPECIFICATIONS

Sealomatic's long experience in the field and extensive facilities enable us to design and build any model to meet your exacting specifications.

KILLION EXTRUDERS

DO-IT-YOURSELF EXTRUSION LABORATORY

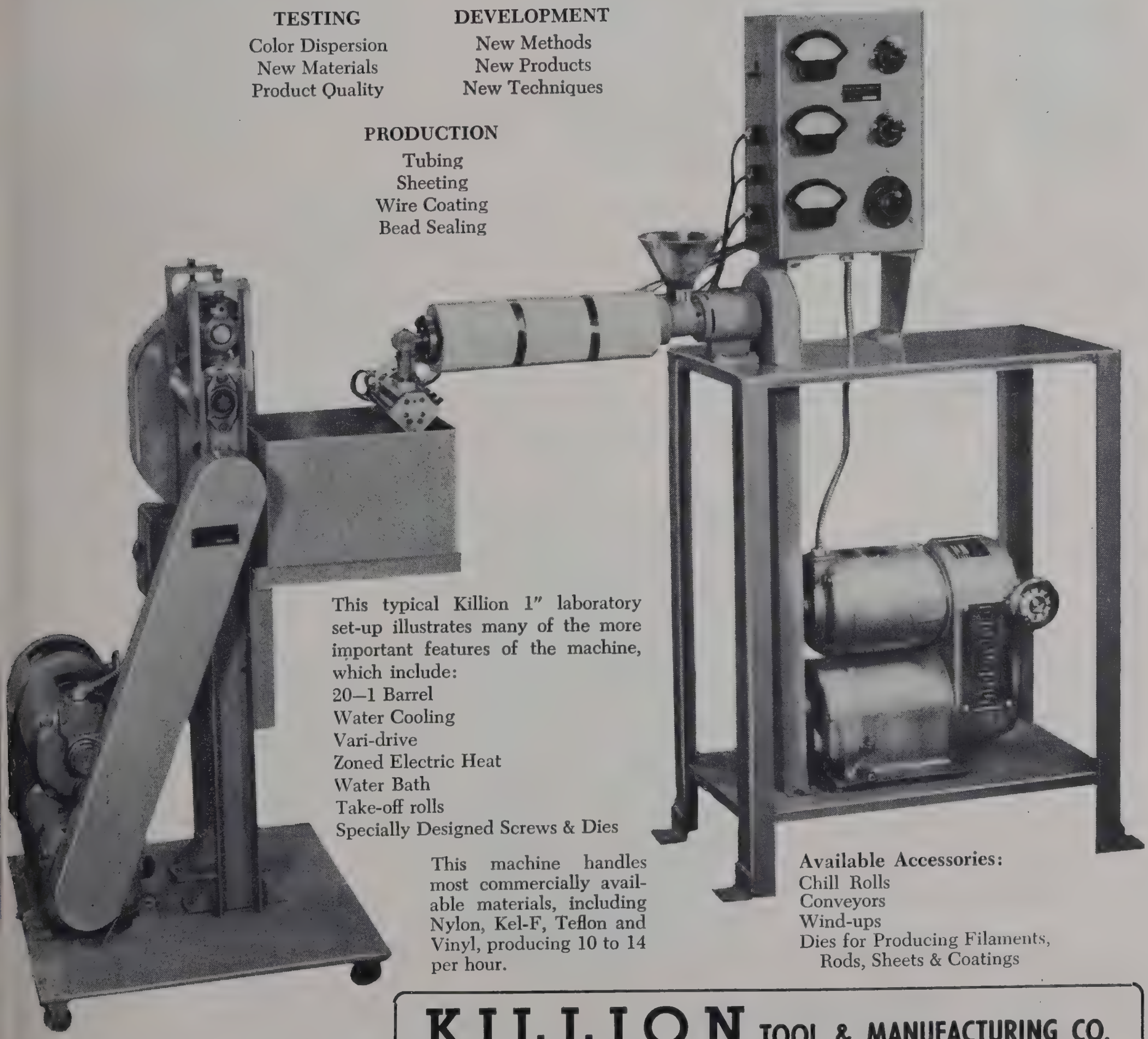
A Killion 1″ Laboratory Extruder is the economical solution to your problems of developing new products or improving your present ones.

In a space not much larger than your own desk, you have your own laboratory for working out problems in:

TESTING
Color Dispersion
New Materials
Product Quality

DEVELOPMENT
New Methods
New Products
New Techniques

PRODUCTION
Tubing
Sheeting
Wire Coating
Bead Sealing



This typical Killion 1″ laboratory set-up illustrates many of the more important features of the machine, which include:

- 20–1 Barrel
- Water Cooling
- Vari-drive
- Zoned Electric Heat
- Water Bath
- Take-off rolls
- Specially Designed Screws & Dies

This machine handles most commercially available materials, including Nylon, Kel-F, Teflon and Vinyl, producing 10 to 14 per hour.

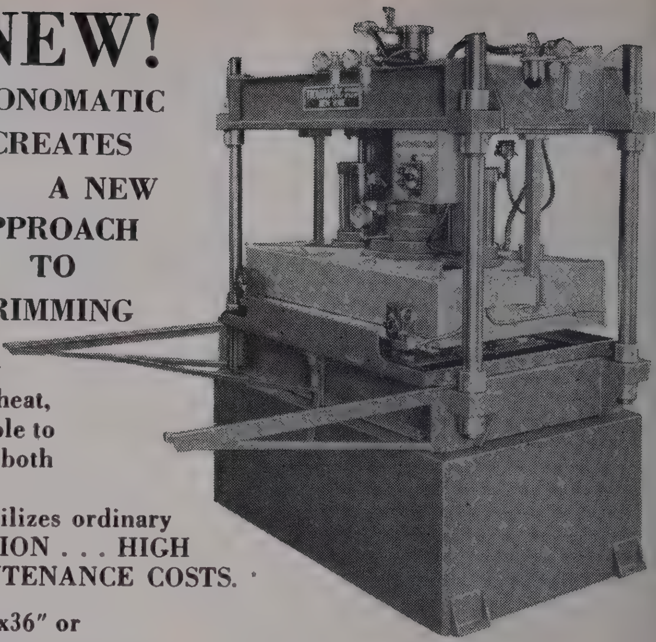
Available Accessories:
Chill Rolls
Conveyors
Wind-ups
Dies for Producing Filaments, Rods, Sheets & Coatings

KILLION TOOL & MANUFACTURING CO.

56 Depot Street, Verona, N.J.

TRONOMATIC
HEAT-ASSIST,
AIR HYDRAULIC
DIE-CUTTING
PRESS

NEW!
TRONOMATIC
CREATES
A NEW
APPROACH
TO
TRIMMING



A new concept in die cutting, permitting nearly unlimited cutting lengths by use of controlled heat, combined with HIGH force at speeds comparable to mechanically operated presses. Accommodates both sheet plastic and complete multiple blister or skin package cards. LOW DIE COSTS . . . utilizes ordinary steel rule dies. HIGH QUALITY PRODUCTION . . . HIGH SAFETY OF OPERATION . . . LOW MAINTENANCE COSTS.

Available in 2 standard sizes (cutting area: 24"x36" or 30"x50"), or custom-engineered to meet your requirements.

TRONOMATIC Can Supply All Your Cutting Die Needs

Wire or Phone Collect For Complete Information

PACKAGING FOR PROFIT

with the new TRONOMATIC blister sealers—ranging from smaller units to fully automated turntable machines—point the way to expanded sales volume with modern blister packaging.

TRONOMATIC MACHINE MANUFACTURING CORP.
1881 PARK AVENUE, NEW YORK 35, N. Y. • SAcramento 2-4611

A
Lawtomatic

A JOY TO OPERATE

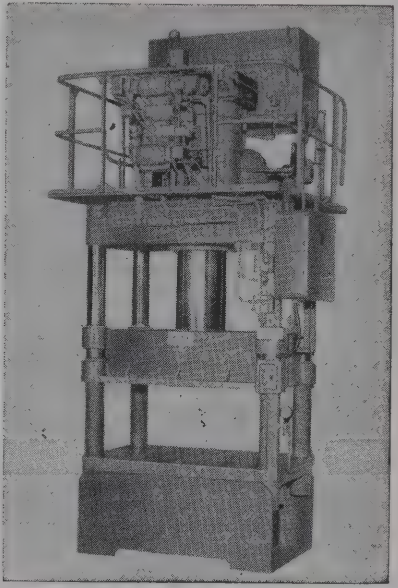
Hydraulic
PRESSES

C FRAME
AIR HYDR.
METAL DRAW
COMPRESSION
TRANSFER
•
COMPACT DESIGN
•
DEPENDABLE WORKERS

A PROFIT TO OWN

Hydraulic
CYLINDERS

ALLOYED IRON
MEEHANITE
STEEL
BRONZE
•
STURDY CONSTRUCTION
•
POSITIVE CONTROLS



(200 TON)

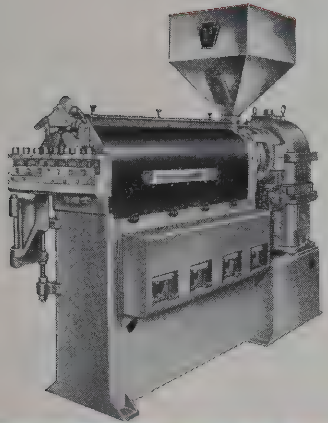
Reinforced Plastic Molding Press
THE C. A. LAWTON COMPANY – DePere 1, Wisconsin

SIZE

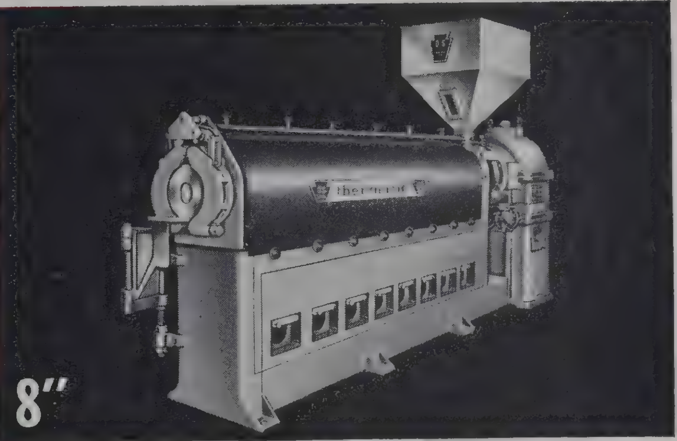
for **SIZE**

A New thermatic Series*

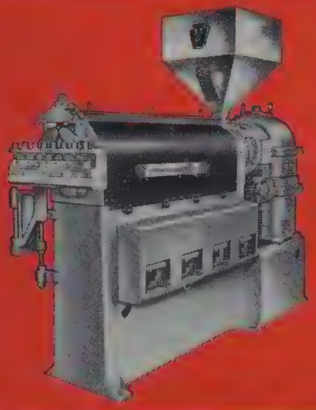
extruder will outproduce any extruder on the market



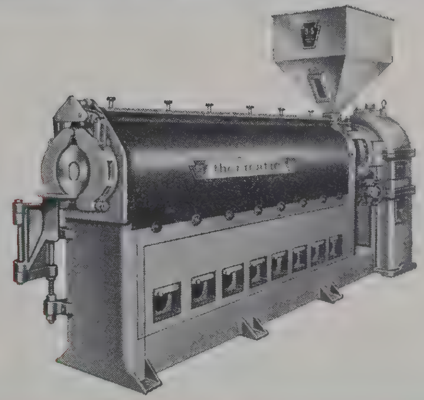
4½"



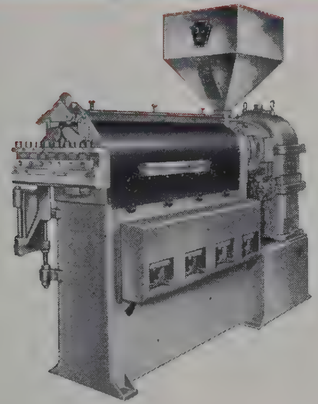
8"



3½"



6"



2½"

	2½"	3½"	4½"	6"	8"
More Horsepower Capacity	64	107	142	209	308
Higher Screw Speeds	200	150	110	85	60
Greater Output (lbs./hr.)*	200	375	600	900	1500

*PE (20,000 mol. wt., 4.0 melt index, 0.92 sp. gr., 500°F., 3000 p.s.i)

*Patented

Complete Details are Available Now. Write or Call

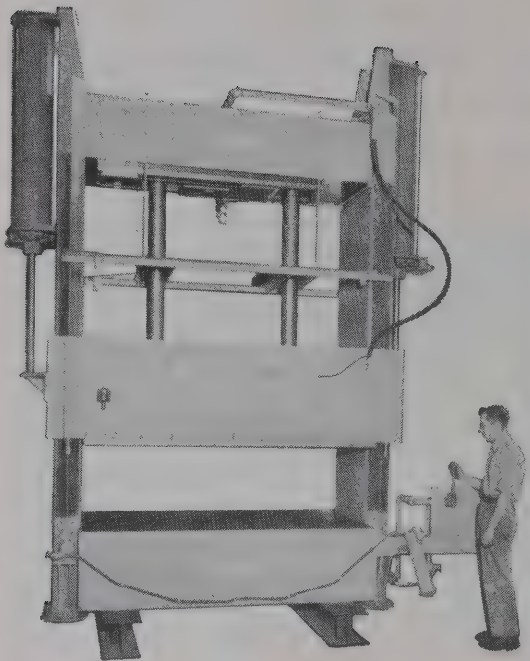
D-S

DAVIS-STANDARD

Division of FRANKLIN RESEARCH CORPORATION

6 WATER STREET, MYSTIC, CONNECTICUT

In Canada contact E. V. Larson Co. Ltd., 572 Queen St. East, Toronto 2, Ontario/in Europe and the Sterling Area contact Fawcett, Preston & Co. Ltd., Bromborough, England/in Chicago contact C. J. Beringer Co., 5522 Milwaukee Ave., Chicago, Illinois.



dk

HIGH SPEED MOLDING PRESS

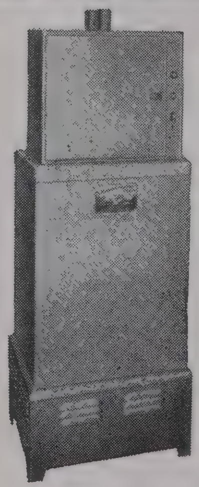
D-K presses have larger, more accessible working area, positive control with fine adjustment on both fast and slow closing speeds and a smooth flow of power. Initial cost is less — operating costs are lower. Stroke, daylight openings and pressures furnished to customer specifications. Write for illustrated brochure.

DAVIDSON-KENNEDY CO.
1090 Jefferson Street, N.W., Atlanta, Georgia

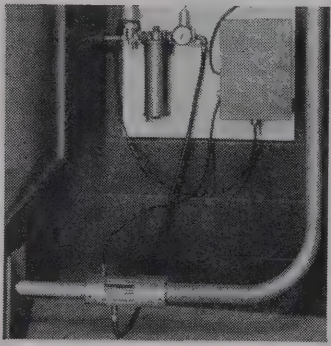
Whitlock The Complete Line of

CONVEYORS • DRYERS • SPECIAL EQUIPMENT

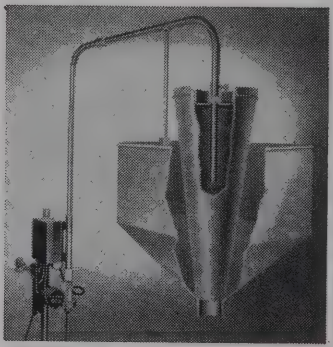
for handling all plastic materials!



Automatic Dryers
Dehumidifies drying air to a minus 20 dew point in a closed system - preheats material - capacities to 600 lbs. per hour.



Bulk Handling Conveyors
Automatic or manual - capacities to 2,500 lbs. per hour.

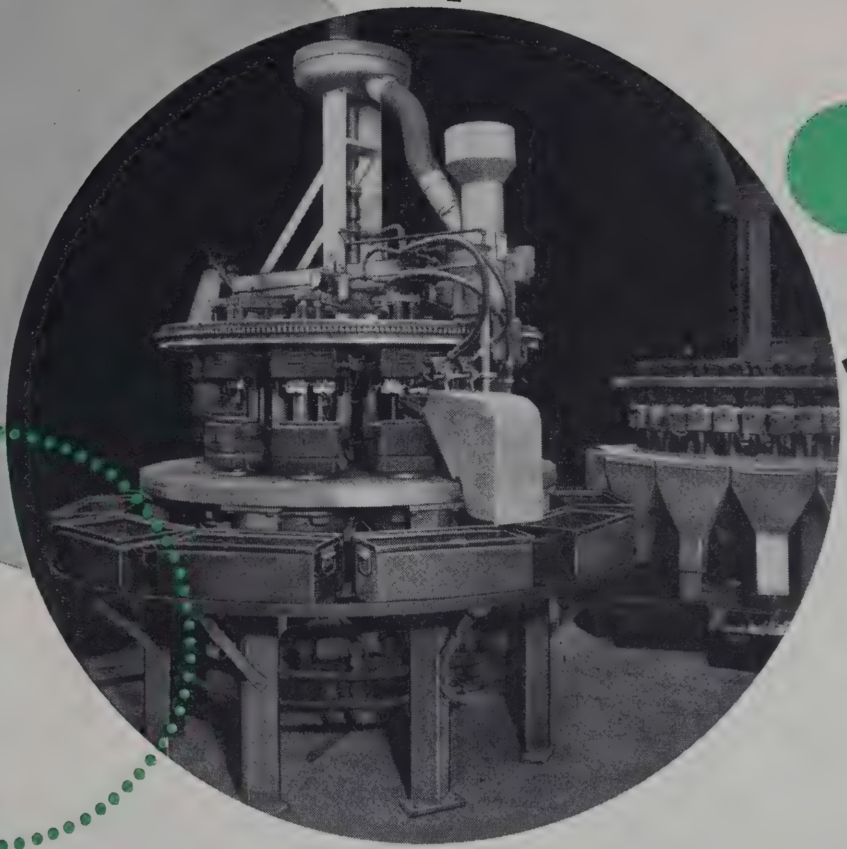


Filter Cone Attachment
Automatic - eliminates dust caused when transferring plastic materials.

Self Supporting Conveyors
Automatic or manual - capacities to 1,200 lbs. per hour.

The Whitlock line gives you both standard and custom built equipment. *Write for complete catalog.*

WHITLOCK ASSOCIATES INC.
21655 Coolidge Hwy., Dept.59-D,Oak Park 37, Mich.



NEBUTTCO

AUTOMATIC ROTARY PLASTIC MOLDING PRESSES

10- or 30-Station Machines

- Low cost simple molds
- Machine easily installed
- Simple ejection of parts
- Easily maintained
- Maximum flexibility
- Fully automatic compression molding
- Hopper feed – the supply rotates
- Adjustable production cycle
- Adjustable temperature in mold holders
- Low cost molding for small quantities
- Molds changed without production interruption

For descriptive bulletin or opportunity to see these machines in operation, contact

NEW ENGLAND BUTT CO.
Division of Wanskuck Co.
304 Pearl Street • Providence 7, R. I.

MAS-coating of a tunnel cover
MAS-coating of the side walls of a clarifying plant
MAS-Spraying of a boat shell
MAS lining of a subterraneaues sewer in a chemical factory.
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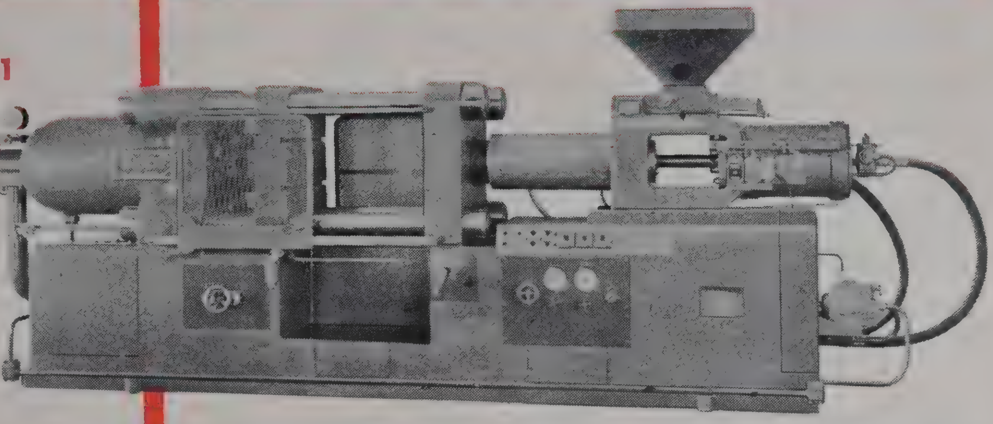
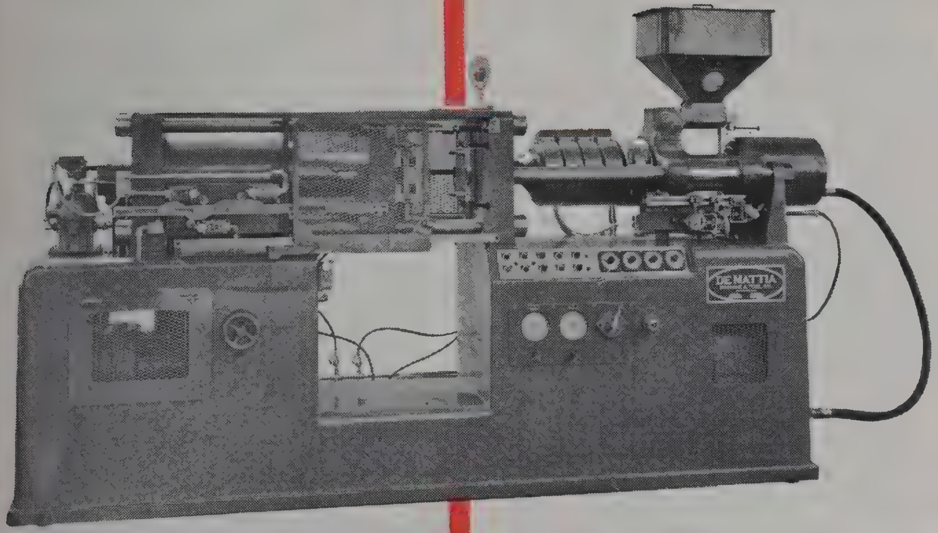
FULLY HYDRAULIC
12/16 oz. MODEL M-1

Proven for maximum production, minimum down time. Fully automatic, with prepack; valves manifold mounted; 12 cycles per minute*; low pressure closing.

Plasticizing Capacity	over 150 lbs./hr.
Maximum Daylight	32″
Clamping Pressure	400 tons
Maximum Mold Size	20″ x 30″ horiz. 16″ x 32″ vert.

*Dry Run





FULLY HYDRAULIC
4/6 oz. MODEL K-2

A completely self-contained unit offering assured performance, fast production. Fully automatic, with prepack; valves manifold mounted; 600 cycles per hour*; low pressure closing.

Plasticizing Capacity	100 lbs./hr.
Maximum Daylight	20″
Clamping Pressure	150 tons
Maximum Mold Size	14″ x 20″ horiz. 12″ x 22″ vert.

*Dry Run

Fifty years of precision-engineered machine building experience assure complete satisfaction with De Mattia installations.

Increased production, reduced costs and over-all efficiency and economy are proven results in every case.

Send for complete data on the De Mattia machine that will solve your production problems.

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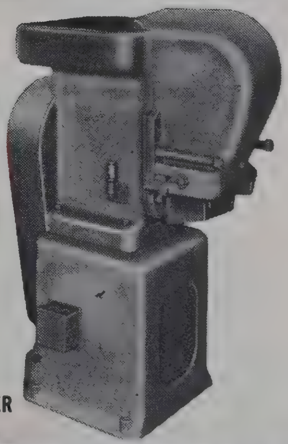
DE MATTIA GRANULATORS

Save by processing your scrap with machine-side De Mattia granulators. Rugged and efficient, they are available in sizes to meet your needs, save you time, money, handling, storage space. Capacities range from 75 to 200 lbs. per hour; various screen sizes.



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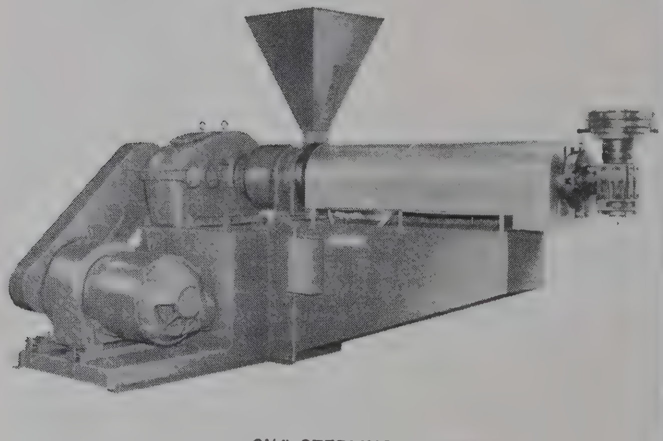
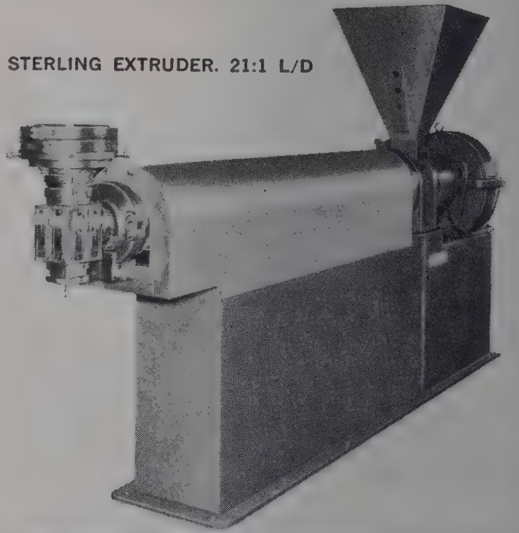
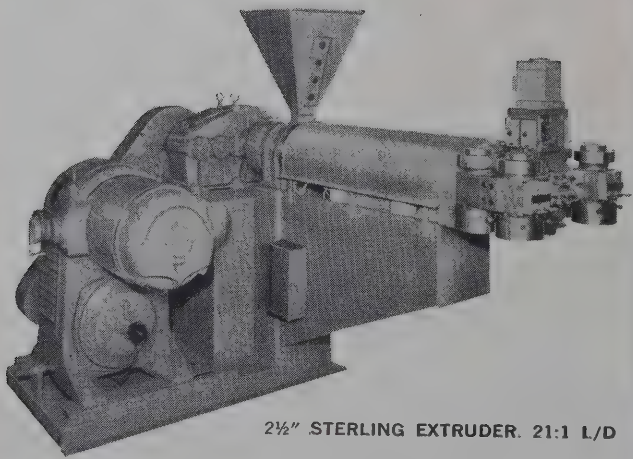
PERFORMANCE



3½" STERLING EXTRUDER. 21:1 L/D

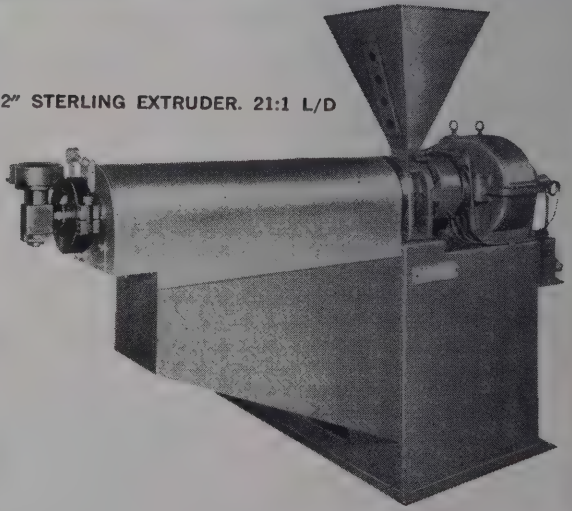
4½" STERLING EXTRUDER. 21:1 L/D





2½" STERLING EXTRUDER. 21:1 L/D

2" STERLING EXTRUDER. 21:1 L/D



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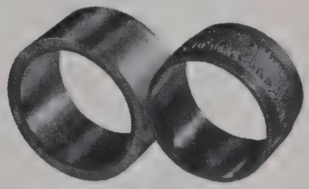
Proven advantages of the use of XALOY and XALOY-306 lined cylinders include tremendously increase production and new long life for e trusion equipment.

Today, XALOY and XALOY-306 lined b metallic cylinders can be supplied i a broad range of lengths, diameters and wall thicknesses.

Industrial Research Laboratories is constantly engaged in research and development in the application of XALOY and XALOY-306 lined cylinders to the broad requirements of industry. Extensive design, engineering and production facilities are available to review your individual requirements.



Proof of Corrosion Resistance of XALOY-306. Both rings were cut from the same steel cylinder lined with XALOY-306. The first section (left) represents the original cylinder with XALOY-306 lining. The second section (right) from the same tube was immersed in boiling 50% hydrochloric acid. This section shows how the XALOY-306 lining remains unaffected, while the steel backing (etched portion) was almost entirely dissolved.

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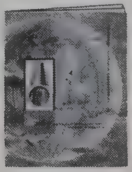

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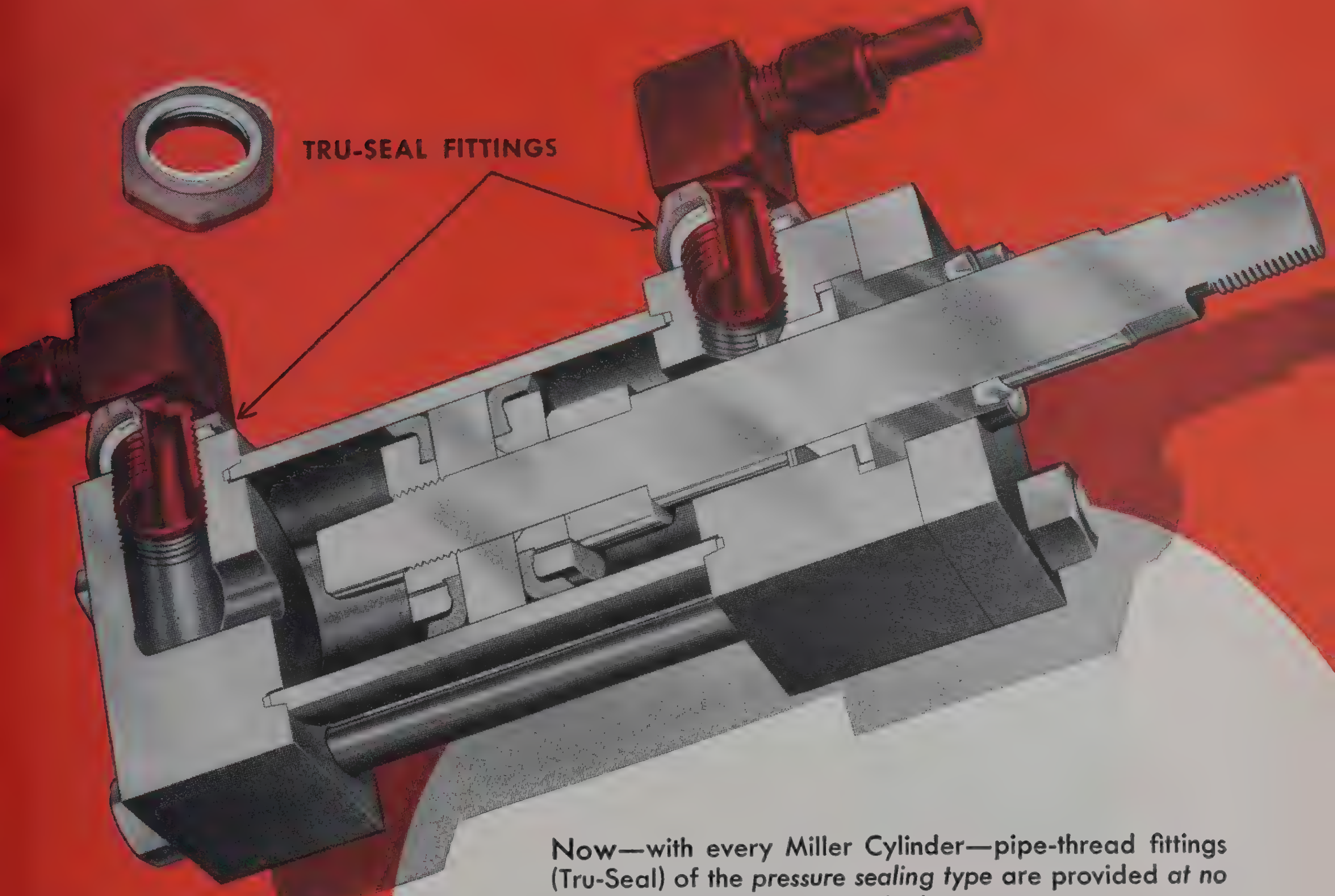

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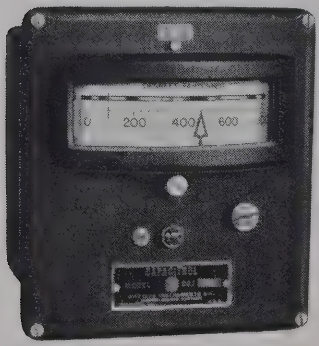
Wheelco's leadership in plastics instrumentation is built on a base of solid performance

Wherever you see a new and modern installation for either plastics injection molding or extrusion — take a close look at the instrumentation. The odds are strongly in favor of finding one or more of the Wheelco instruments illustrated below on the newest and finest equipment built to handle the most exacting jobs.

Both equipment builders and plastics industry engineers base their choices on performance — nothing else. Basic to the performance story are the precise control of critical temperatures, flexibility and dependability of operation, and simplified maintenance resulting from designs making liberal use of plug-in components.

Wheelco provides other benefits, too, including training courses for your instrument technicians and supervisors and the backing of a nationwide sales and service organization thoroughly familiar with equipment designs and manufacturing problems.

Brief, factual descriptive literature is available for indicating controllers, recorder-controllers, and recorders shown here. Copies are available from your nearby Wheelco branch office or by writing to address below.



290 Series indicating controllers offer precise temperature control at a surprisingly low cost.

Finest indicating controllers available, 400 Series instruments are available in six control forms.

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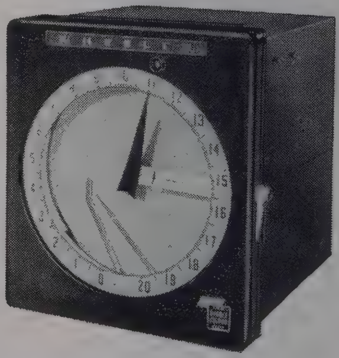

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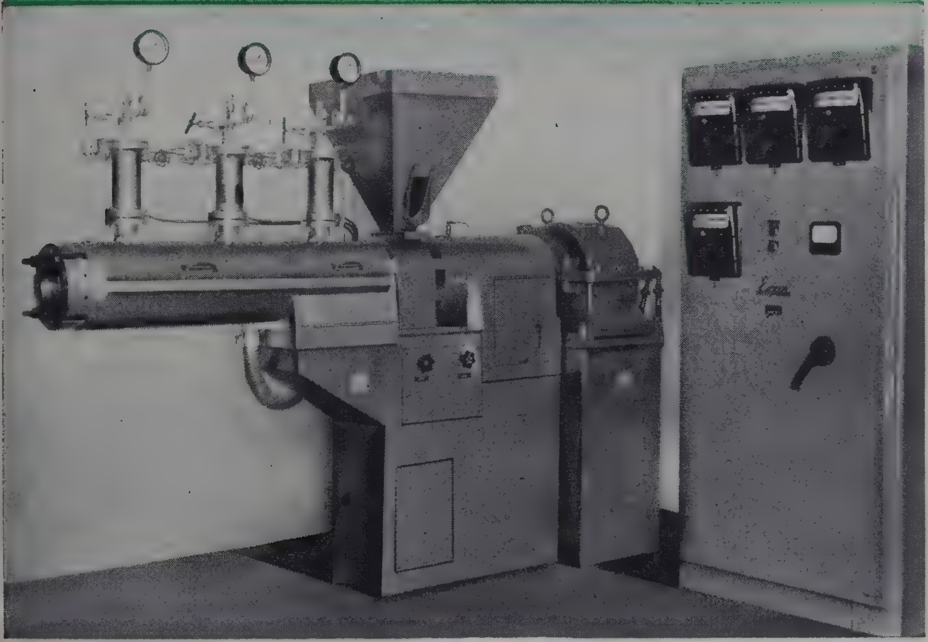

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☐ with "Willert Automatic Temperature Control" available in sizes from 2″ through 12″, vented or non-vented

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210 ounces per Shot

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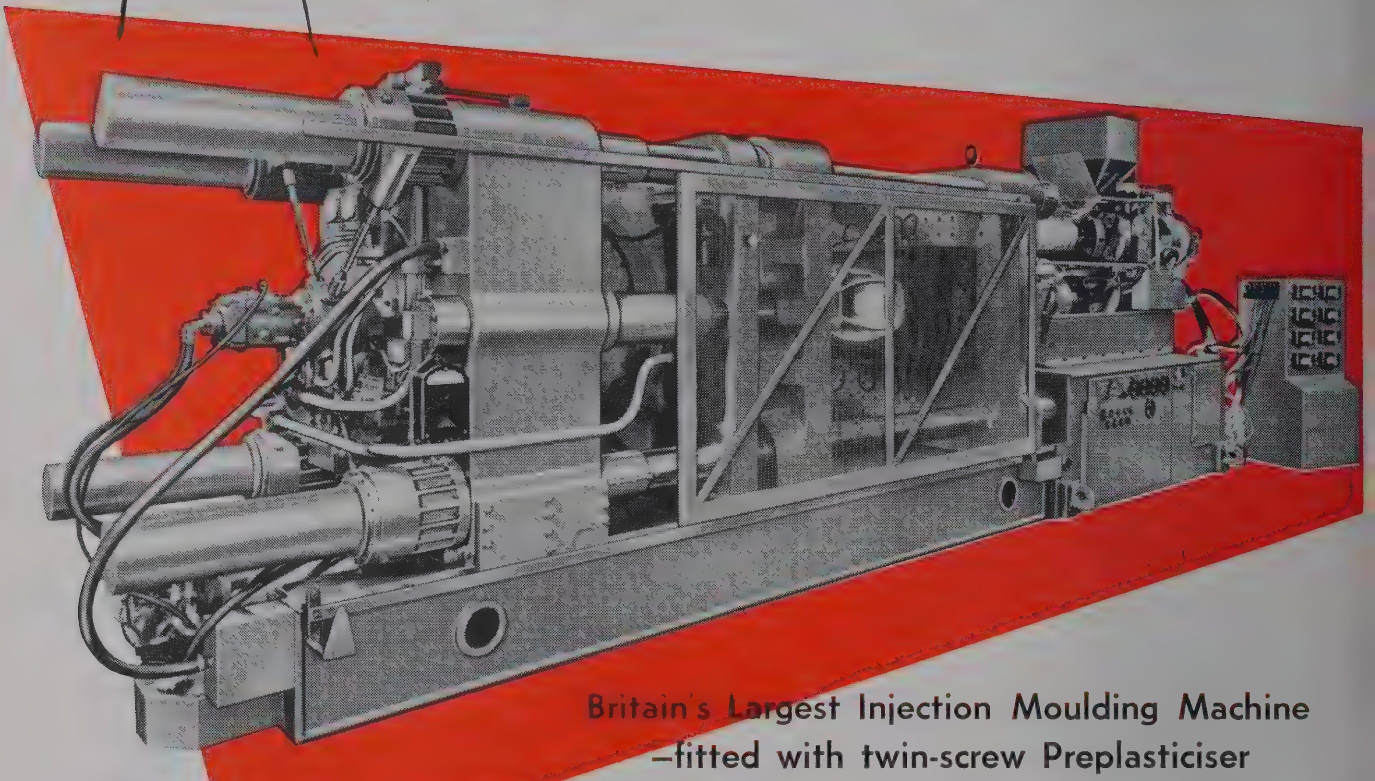
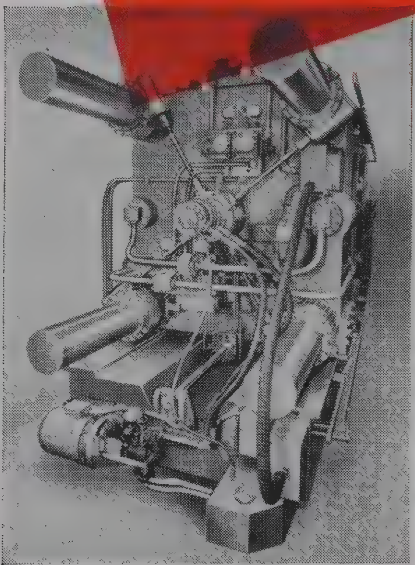
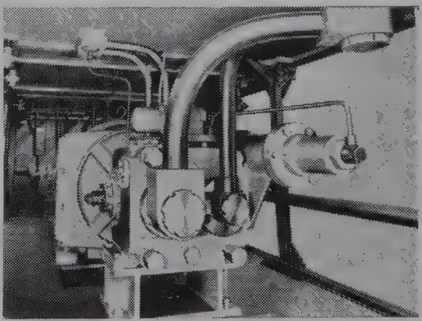


Britain's Largest Injection Moulding Machine —fitted with twin-screw Preplasticiser

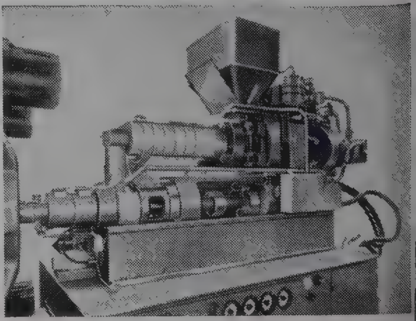
The AP335, 73 tons of craftsman built precision machinery, produces high quality, stress-free mouldings up to 210 ozs. in weight. A plasticizing capacity of 420 lbs. per hour is obtained with the 2 stage injection unit which incorporates the Windsor Autoplas twin-screw preplasticizer.



Hydraulically operated mould height adjustment.



Power unit showing main pump and 150 h.p. motor.



Two stage injection unit incorporating the twin-screw Autoplas.

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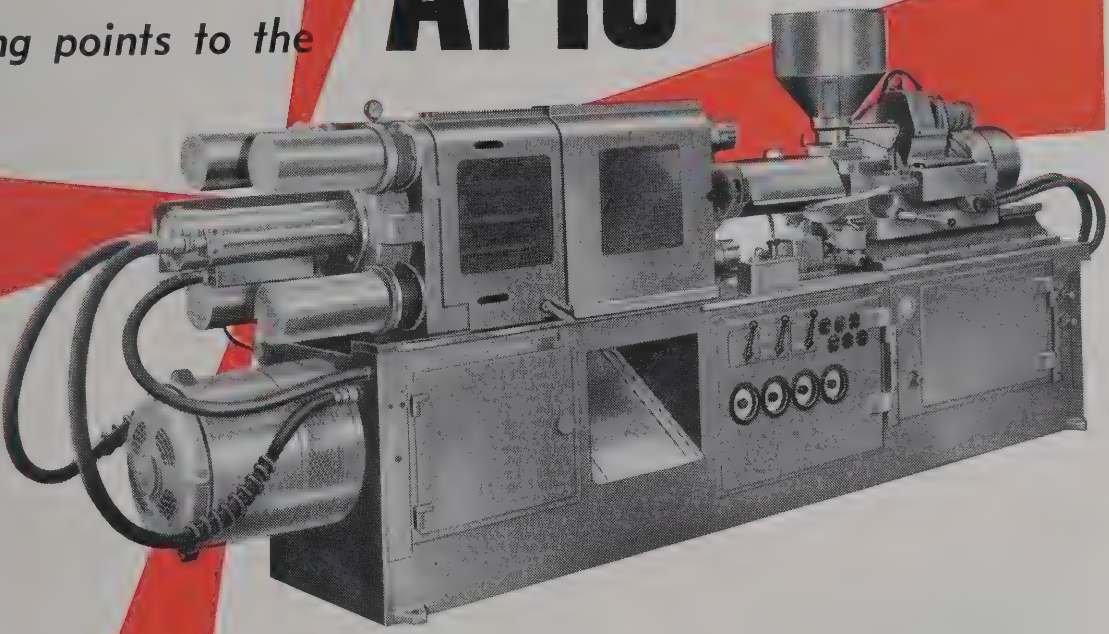
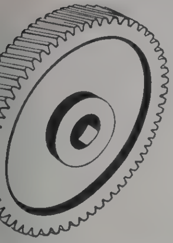
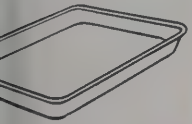
For *STRESS FREE* Mouldings up to 14 ounces ...

everything points to the

AP16







Latest Addition to the WINDSOR Range of Preplasticiser Injection Moulding Machines

The Windsor range includes: INJECTION MOULDING MACHINES from 1 to 210 ounces and EXTRUSION MACHINES with outputs up to 450 lbs. per hour

FEATURES OF THE AP16 include

LATEST IN-LINE PREPLASTICISER
incorporating quick release system for ease of screw change.

LARGE PLATEN AREA
Side and centre ejectors fitted.

BALANCED TOGGLE LINKAGE
designed to exert a clamping force of 175 tons.

REMOVAL OF UPPER TIE-BAR
to accommodate moulds not normally adaptable may be achieved without affecting mould plate alignment

SELF CONTAINED MOULD HEIGHT ADJUSTMENT
by geared drive ensuring accurate alignment.

HYDRAULIC PUMPS
and directional control equipment are housed within the base of the machine and are readily accessible.

STRAIGHT TROUGH CHUTE
with reversible slide.

ELECTRICAL CONTROL EQUIPMENT
centrally located with readily accessible controls.

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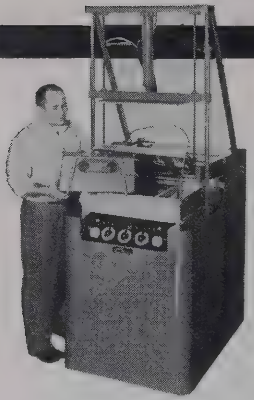

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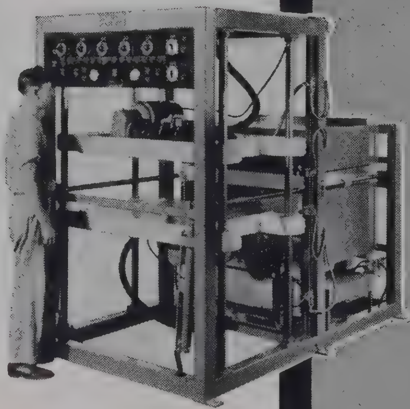
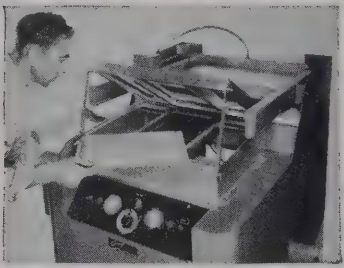


COMET STAR
Snapback Forming, Pressure Forming, Mechanical Forming, Light Trimming, all incorporated into one machine.



COMET LABMASTER (Model 1420)
Close-up view of single platen laboratory and sampling machine.

- **Sheet Plastic Forming of Products**
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Many parts and products now made from metal, wood, fibre and glass can be produced in Plastic by Comet Vacuum and Blister Forming at considerable savings.

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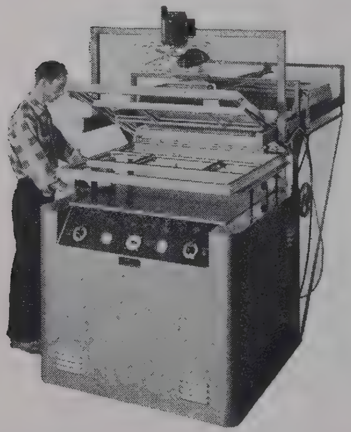

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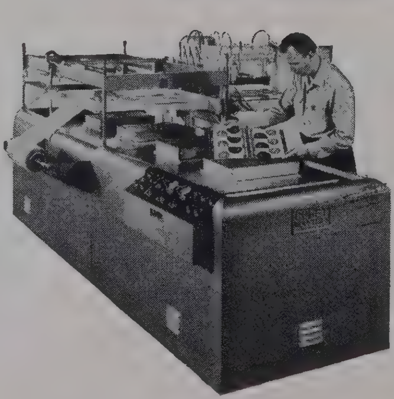
Economical Drape and Vacuum Forming Machine. Completely automatic for Vacuum Forming or Skin Packaging.



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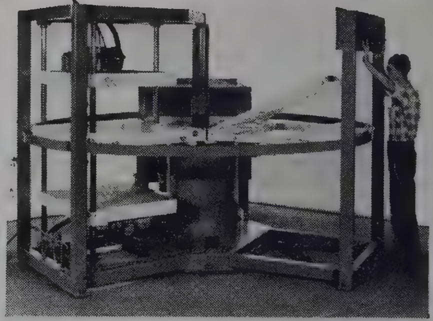

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Three station vacuum forming machine for high production.

Vacuum, Drape and Snap-Back Forming. Operator loads and unloads at one station — all other operations fully automatic. Also available with male assist.

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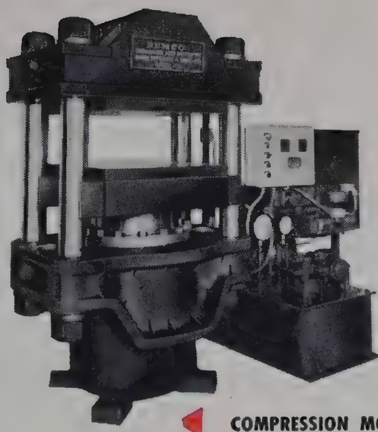

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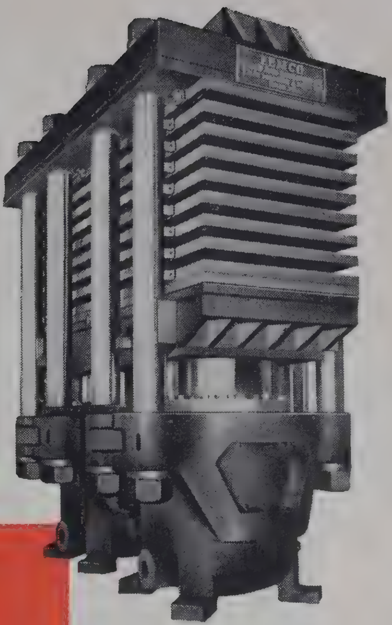

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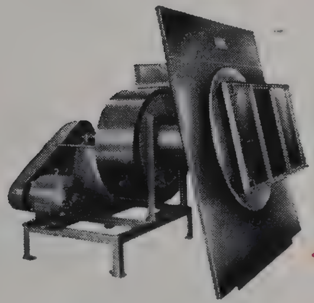
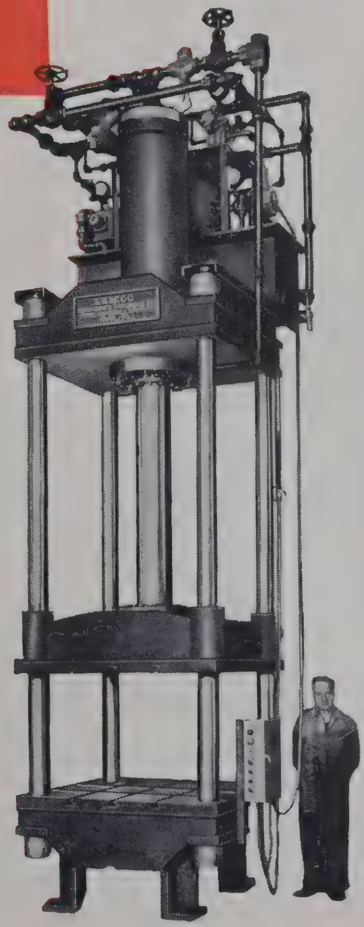
Let us quote on our standard units or build to your specifications.



FIBERGLASS PREFORM MACHINE



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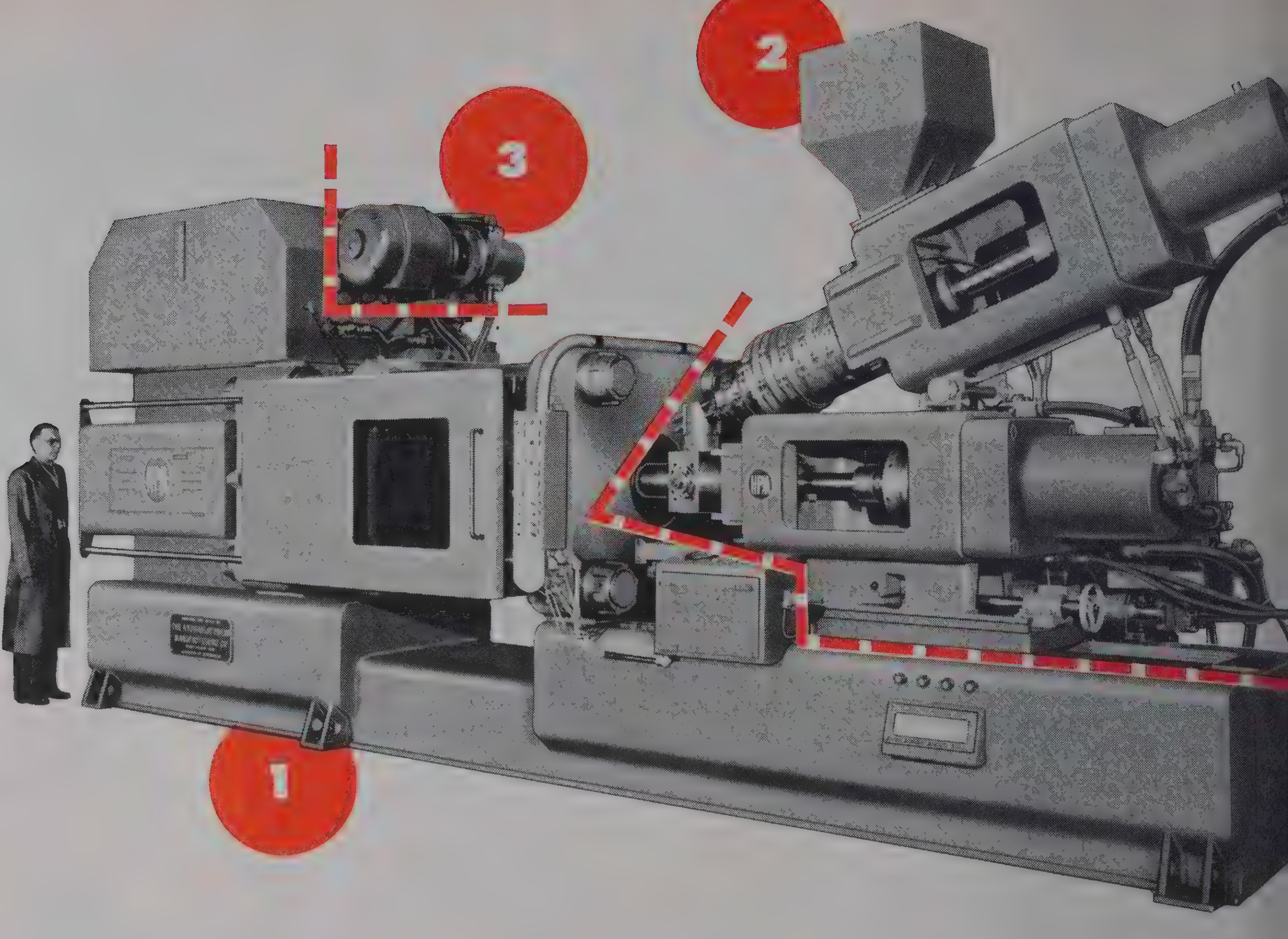


HOW TO CUT COSTS ON TOUGH MOLDING PROBLEMS

This 80 oz. H-P-M preplasticizer with 650-ton clamp is a typical example of adapting standard H-P-M pre-engineered machine elements for special molding requirements. These special "standards" have saved molders up to $15,000 in machine costs. For example, on the above machine:

1 — The basic clamp frame is from a standard model 650-HV-32/42 with an alternate injection end. The machine is capable of 80 oz. shots instead of the normal 32/42 oz. capacity.

2 — The injection end is "borrowed" from a conventional 450-P-80 preplasticizing machine. Machine provides injection rates of 3300 cu. in. per minute.

3 — The unusually high injection rate of 3300 cu. in. per min. is obtained with a 30 HP booster power unit, raising the rate from the conventional 2435 cu. in. per minute. This machine also available with 50 HP booster power units for rates up to 5015 cu. in. per min.

Other optionals include low pressure mold closing; automatic cycle control with cycle open timer; nylon nozzle kits; automatic lubrication; multiple nozzle arrangements; special heating chambers; special clamp circuits, stroke interruptions and prepositioning to clear knockouts.

All elements are pre-engineered, providing maximum production potential with only minor engineering charges for special adaptations.

CONVENTIONAL INJECTION MOLDING MACHINES COVER WIDE RANGE OF JOBS

Model	200 H 6/8A	350 HV 12/16	450 HV 20/28	650 HV 32/42	1000- HV- 48/64	1500 H 80/10
Material Injected Per Cycle (oz.)	6-8	12-16	20-28	32-42	48-64	80-10
Material Injected (Cu. In. Per Min.)	675	1230	1450	2510	3920	3320
Plasticizing Capacity (Lbs. Per Hr.)	90	150	200	300	300	400
Mold Clamp Capacity (Tons-Max.)	200	350	450	650	1000	1500
Platen Size (In.)	26x26	34x34	36x42	48x48	60x60	72x7
Clearance Between Tie Rods (In.)	15½x15½	20½x20½	21x27	30½x30½	39½x39½	48½x4
Daylight Opening (Max. In.) Without Ram Spacer	25	34	40	50	65	106
With Ram Spacer	21	30	34	42	57	94
Daylight Opening (Max.-In.) With Ejector Box Removed	29	42	48	58	79	120
Mold Thickness (Min.) w/o Ram Spacer (In.)	10	12	15	20	20	46
Mold Space (Min.) With Ram Spacer (In.)	6	8	9	12	12	34
Clamp Travel (Max.)	15	22	25	30	45	60
Motor Horsepower	30	60	75	107½	180	150
Shipping Weight (Lbs.)	17,000	32,500	42,700	70,000	114,000	202,5

NOTE: All injection capacities specified above are for general purpose polystyrene

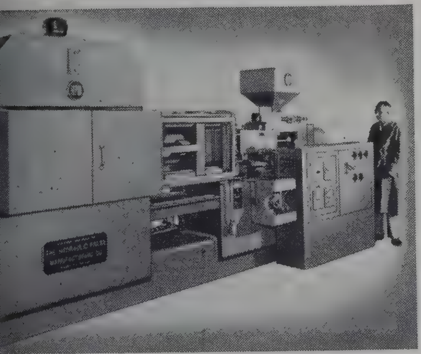
H-P-M PREPLASTICIZING MACHINES FOR BETTER QUALITY PARTS, FASTEST INJECTION

Machine Model	200-P 28	350-P 2[illegible]	450-P 80	Long Stroke 450-P-80	650-P 140	1000-P 200	150 30
Material Injected Per Cycle (Oz./Max.)	28	28	80	80	140	200	30
Clamp Tonnage	200	350	450	450	650	1000	15
Plasticizing Capacity (Lbs. Per Hr.)	90	150	200	200	300	300	40
Mold Space (Max. In.)	15x26	20 x 34	20½x42	20½x42	30x48	39x60	48x
Daylight (In.)	25	34	40	54	50	65	10
Mold Thickness (Min. Without Spacer) (In.)	10	12	15	20	20	20	4
Stroke (In.)	15	22	25	34	30	45	6
Rate of Injection (Cu. In./Min.)	1350	1210	1530	1530	2510	4050	66
Horsepower	50	60	75	75	107½	180	2
Shipping Weights (Lbs.)	20,000	37,000	51,200	54,700	85,000	129,500	221

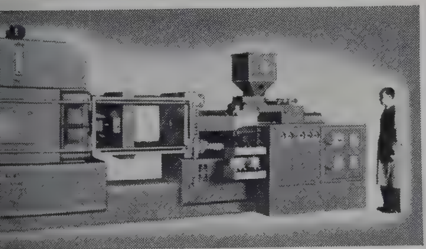
NOTE: Machines can be equipped for higher speed injection if desired.

cial 6 oz. machine with 20 HP booster power . 1350 cu. in. per min. injection rate instead conventional 675. Booster unit may also be l to operate core pulls or unscrewing devices nolds. 25″ or 30″ daylight optional.

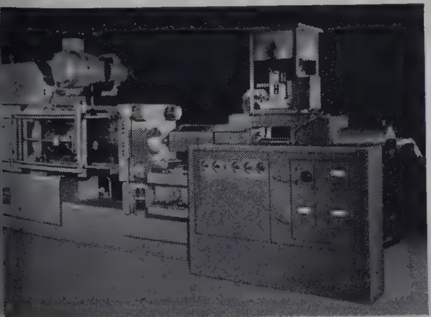
ndard 6-oz. machine, ideal for general purpose lding. Available with weigh feeder and all ional features mentioned above. This model o available with P-28 preplasticizer.



P-M model 200-H-6/8A, with long stroke and ylight, is a special machine for deep drawn rts. Available with 42″ daylight and 24″ stroke. l optional features shown are adaptable.

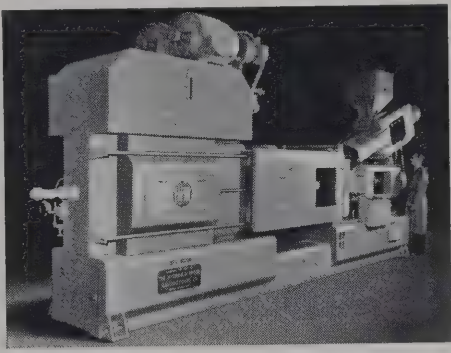


nis 12 oz. machine is designed for high speed peration—it's the fastest machine available toy. This, too, may be equipped with standard ptional features for a variety of adaptations om standard.

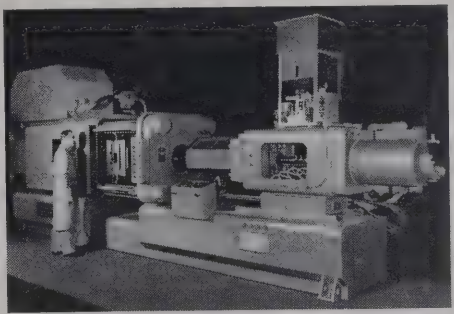


he 12 oz. machine for difficult molding jobs. his special Model 350-HV-12/16 is equipped ith a 30 HP booster unit increasing injection ite from 1230 cu. in. to 2110 cu. in. Extra long roke and daylight are also available.

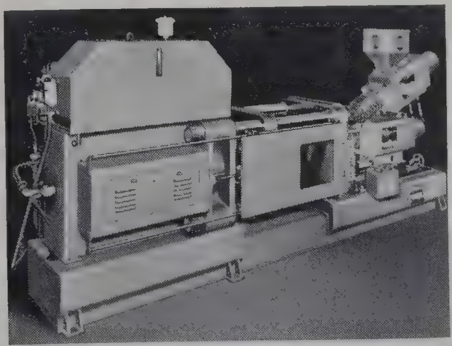
A medium size, general purpose machine especially designed for all-purpose production. Model 450-HV-20/28 has a fast, 75 HP system . . . was the first to offer fast cycling speeds in the medium size machine range. All optionals available for added versatility.



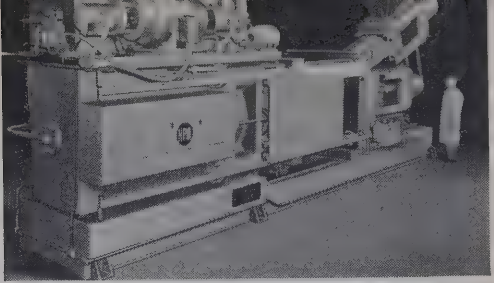
H-P-M 80 oz., a necessary machine for the molder of housewares. Deep drawn parts need exceptionally fast mold filling. Power available for injection rates from 1460 cu. in. per min. to 4040 cu. in. per min. Machine shown has 4040 cu. in. per min.



This 32 oz., a good general purpose machine, is used extensively in the automotive industry. Model 650-HV-32/42 fits the wide gap between intermediate and large machines, has complete optional features including either 30 or 50 HP booster units for injection speeds of 3375 or 3800.

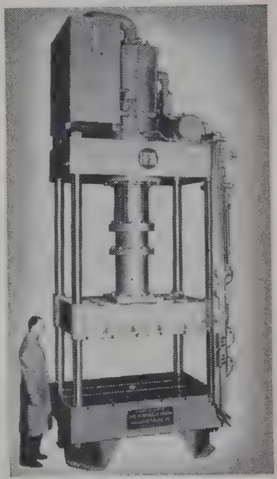


This 80 oz. model is another example of custom designing with standard injection machine elements. Standard clamp and injection end used from two different machines. Large inventory permits delivery of this "special" in four weeks.

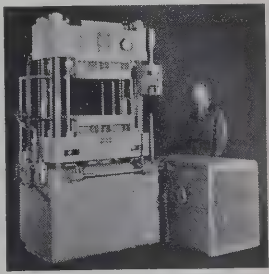


H-P-M's 1000-P-200 is a brand new model designed for the molder's ever-changing requirements. Standard model has 79″ daylight, 45″ stroke, 4050 cu. in. injection rate. 50 HP booster unit raises injection to 5300 cu. in.

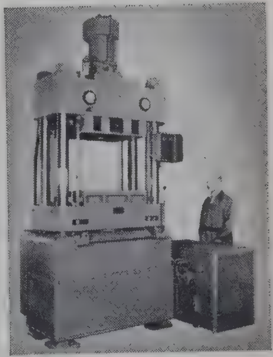
The 300 oz. has been the leader in this size range since 1957. Daylight 120″; stroke 60″; injection rate 6600 cu. in. per min. A giant machine for exceptionally difficult molding produces huge parts once thought impractical to attempt.



Stock H-P-M presses designed specifically for molding reinforced plastics range in sizes of 100, 150 and 200 ton capacities. Equipped for semi-automatic control, fast closing, automatic slowdown, completely adjustable for speed and pressure.



H-P-M self-contained compression molding presses for thermo-setting plastics. Completely hydraulic, they are arranged to operate semi-automatic molds equipped with knockouts. Stock sizes—100, 200, 300 and 500 tons with larger sizes to 2500 tons available on order.



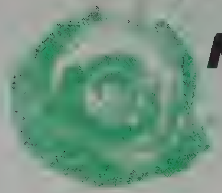
H-P-M transfer presses permit low cost molding of thermo-setting plastics. Designed to permit incorporation of various types of inserts with no trouble. Stock sizes 100, 200, 300 and 500 tons. Larger presses on order.

THE HYDRAULIC PRESS MFG. COMPANY

HPM

H931

A Division of Koehring Company, Mount Gilead, Ohio, U.S.A.



MACHINERY AND EQUIPMENT

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INJECTION MOLDING MACHINES	Clifton Hydraulic Press Co., Clifton, N.J.	FELLOWS GEAR SHAPER CO., SPRINGFIELD, VT.				LEWIS WELDING AND ENGINEERING CORP., CLEVELAND, OHIO		
1. Model No.	357	3-125	6-200	6-10-225	12-350	412-D-8	616-L-12	616-PP-12
2. Oz. of GP Ps molded per shot	2¾	3	6	6-10	12-20	2.6[2] 5.0[3]	8[2] 12[3]	21
3. Cu. in. molded per shot	–	4.6	9.6	9.6-16	19.5-33	8.0	20	34
4. Locking force, tons	90	125	200	225	350	100	200	200
5. Max. daylight opening, in.	18	22	23	32	44	20	28	28
6. Plasticating capacity, lb./hr.	60	45	75	100	150	50	100	150
7. Maximum mold size, H x V, in.	12 x 12	12 x 18½	15 x 22	15 x 25	20 x 33	21 x 14	24 x 14¾	24 x 14¾
8. Mold clamping stroke a. Min., in.	6¾	5	6	8	10	No minimum		
b. Max., in.	6¾	8	9	14	20	8	12	12
9. Rated casting area, sq. in.	20	30	70	78	115	60	120	120
10. Inj. plunger stroke a. Max., in.	8	5½	8½	10½	10½	8	9½	9½
b. Min., in.	8	–	–	–	–	4	4½	4½
11. Max. injection speed, cu. in./sec.	3½	6	8.75	8.75-10.7	17.4	2.7	4.0	10.0
12. Max. injection rate at 15,000 p.s.i., cu. in./sec.	3½	–	–	–	–	–	–	–
3. Top ram pressure, p.s.i.	2000	Up to 30,000 p.s.i. with reduced size plunger				21,200	20,400	25,200
14. Min. dry cycle time, sec.	13	6-4.3	7.3-5.4	4.4-4.2	6-4.5	8	10	10
15. Motor, hp.	10	15	20	20 or 30	40	10	25	25
16. Degree of automation	f.a.& s.a.[1]	Semi-automatic or fully automatic				Semi-automatic or fully automatic		Semi-automatic
7. a. Are molds protected against closing on obstruction?	Yes; low pressure closing	Low pressure closing is optional				Yes	Yes	No
b. Is weigh feeder included?	No	Optional				No	No	No
c. Are precompressed molding feature included?	No	Optional				No	No	No
8. Approx. price range, $	6500	Prices on application				11,950	20,700	24,950
9. Approx. delivery time, weeks	6	–	–	–	–	8	12	12

CLIFTON: [1]f.a. – fully automatic; [1]s.a. – semi-automatic;   LEWIS WELDING: [2]Single shot; [3]Prepack

INJECTION MOLDING MACHINES	LOMBARD GOVERNOR CORP., ASHLAND, MASS.						F. J. Stokes Corp. Phila., Pa.	
1. Model No.	2414-6	3214-12	3220-125	3220-16	3220-165	3624-18	701	703
2. Oz. of GP Ps molded per shot	6	12	12	16	16	18	2	6
3. Cu. in molded per shot	10	20	20	26	26	30	3.25	9.8
4. Locking force, tons	215	325	325	325	325	450	50	250
5. Max. daylight opening, in.	32	36	42	42	42	50	14-20½ Adjustable	26-34
6. Plasticating capacity, lb./hr.	150	150	150	200	200	200	40	80
7. Maximum mold size, H x V, in.	28 x 14⅞	36 x 20	36 x 20	36 x 20	36 x 20	38 x 23¾	15 x 8½	24 x 1
8. Mold clamping stroke a. Min., in.	6	8	8½	8½	8½	8	5½	12
b. Max., in.	14	14	20	20	20	24	5½	12
9. Rated casting area, sq. in.	–	–	–	–	–	–	20	75
10. Inj. plunger stroke a. Max., in.	10	12	12	12	12	12½	4½	9
b. Min., in.	10	12	12	12	12	12½	–	–
11. Max. injection speed, in./sec.	7.16	5.3	6.83	5.3	6.8	6.8	50	78
12. Max. injection rate at 15,000 p.s.i., cu. in./sec.	15	18.5	24.0	18.8	24.1	24.1	–	–
13. Top ram pressure, p.s.i.	20,000	20,000	20,000	20,000	20,000	20,000	17,500	20,000
14. Min. dry cycle time, sec.	4	6.9	5.1	8.6	6.9	7.0	4	6
15. Motor, hp.	25	30	50	30	50	50	7½	20
16. Degree of automation	Fully automatic						Fully automatic	
17. a. Are molds protected against closing on obstruction?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
b. Is weigh feeder included?	Optional	Optional	Optional	Optional	Optional	Yes	No	No
c. Are precompressed molding features included?	Yes	Yes	Yes	Yes	Yes	Yes	Standard equipment	
18. Approx. price range, $	22,000	28,000	32,000	32,000	34,000	37,000	11,000	23,000
19. Approx. delivery time, weeks	–	–	–	–	–	–	3	4

F. J. STOKES: Both models listed have positive ejection as standard equipment.

	REED-PRENTICE DIV., E. LONGMEADOW, MASS.								Simplomatic Mfg. Co., Chicago, Ill.
1.	175T-4/6	JETFLO6	275TA	325TC-12/16	450T-20/24	600T-32/48	175 TL-4/6	350TL-12/16	PRO-1-57
2.	4-6	6	8-10	12-16	20-24	32-48	4-6	12-16	⅓
3.	5	10	13.1	16	29	42	5	16	–
4.	175	175	275	325	450	600	175	350	7000 lb. @125 p.s.i.
5.	22	22	27¾	36½	40	56	26	44½	2⅛
6.	75	100	120	135	150	180	75	135	6
7.	22 x 13½	22 x 13½	27 x 15½	32½ x 20½	45 x 25½	54 x 30½	22 x 13½	32½ x 20½	2½ thick 3½ high 5¼ long
8. a.	5	5	6¼	7½	–	–	6	8½	–
b.	8	8	11½	14½	16	24	12	20	2¼
9.	75	75	125	150	200	300	75	150	6
10 a.	8⅞	6	11	11⅝	13	10	8⅝	11⅝	2½
b.	–	–	–	–	–	–	–	–	–
11.	8.15	10.5	13.4	22.8	16	24.2	8.15	22.8	–
12.	–	–	–	–	–	–	–	–	–
13.	17,800	17,000	20,000	19,700	21,000	19,350	17,800	19,700	3500 lb. @125 p.s.i.
14.	5.7	1.3 (min. stroke) 2.9 (full)	8	6.7	18.6	21	7.2	9	50-500 cycles/hr.
15.	15	40	25	40	40	50	15	40	Air operated
16.	Fully automatic		Semi-automatic				Fully Automatic	Semi-Automatic	F. A. or manual
17a.	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
b.	Optional	No	Optional						No[1]
c.	No	Yes	No	No	No	No	No	No	–
18.	17,000	27,500	23,600	30,000	44,000	56,300	20,000	32,000	1000
19.	4-6	6-8	6-8	6	12	12	6	8	5-6

SIMPLOMATIC: [1] Hopper, however, is designed to control volume of material being fed into cylinder automatically.

INJECTION MOLDING MACHINES	GUY P. HARVEY AND SONS CORP., LEOMINSTER, MASS.					STANDARD TOOL CO., LEOMINSTER, MASS.	
1. Model No.	J-1½ J-1½ (High speed)	J-2	J-4	K-1	4F	SA-20-25-T	SA-20-100 T- SA-20-100 T-
2. Oz. of GP Ps molded per shot	1½	2	4	–	4	2	2
3. Cu. in molded per shot	–	–	–	–	–	3.2	3.2
4. Locking force, tons	37½	50	66½	10	120	25	100
5. Max. daylight opening, in.	15	15	15	6	18	12¾	T-A-12¾ T-B-18
6. Plasticating capacity, lb./hr.	40	50	75	10	60	30 or 40	30 or 40
7. Maximum mold size, H x V, in.	12 x 12	12 x 12	12 x 14	6 x 6	14 x 18	9 x 12	9 x 12
8. Mold clamping stroke a. Min., in.	5	5	5	0	7	–	–
b. Max., in.	15	15	15	7	11	6¾	T-A-6¾ T-B-9
9. Rated casting area, sq. in.	–	–	–	–	–	20	60
10. Inj. plunger stroke a. Max., in.	Plunger stroke not adjustable					4	4
b. Min., in.						–	–
11. Max. injection speed, cu. in./sec.	–	–	–	–	–	6.5	6.5
12. Max. inj. rate at 15,000 p.s.i., cu. in./sec.	–	–	–	–	–	–	–
13. Top ram pressure, p.s.i.	20,000	20,000	20,000	12,000	20,000	2000	8600
14. Min. dry cycle time, sec.	3	3	5	–	6	2	T-A-2 T-A-3
15. Motor, hp.	5 High speed uses 7½	7½	10	5	15	10[1]	20
16. Degree of automation	Fully automatic			Semi-automatic	Fully automatic	Semi-automatic and fully automatic	
17. a. Are molds protected against closing on obstruction?	Optional attachment			Yes	Yes	Low pressure closing optional	
b. Is weigh feeder included?	No	No	No	No	No	Adjustable volumetric material feed control	
c. Are precompressed molding features included?	No	No	No	No	No	No	No
18. Approx. price range, $	Reg. – 5000 High speed – 5500	6400	10,000	6000	15,000	–	–
19. Approx. delivery time, weeks	8	8	–	–	–	–	–

GUY P. HARVEY: Many optional features available. Same specifications apply to "H" models which are vertical versions of above. The K-1 and 4F have vertical acting clamps used a lot for insert work.

STANDARD TOOL: [1]20 hp. motor used when more than 1 machine driven from unit.

Full hydraulic clamp available on all models. Variable speed cam cycle control. Hydraulic drive unit for 1, 2, or 3 machines. OPTIONAL EQUIPMENT: Instrument stand; adaptor plate; extra accumulator bottle; air sweep; extra heat control for hot runner molds; 40 lb./hr. plasticizing cylinder (additional).

	IMPROVED MACHINERY, INC., NASHUA, N. H.							British Mach. & Foundry Supplies Ltd. Pt. Washington, New York
1.	CB-30-175	HA 2-125	HA 4-175	HA 8-275	HA 12-300 HB 12-300	HA 16-425	HA 28-600	APM 22
2.	2	3	4-6	8-10	12-16	20	32	¾
3.	–	–	–	–	–	–	–	–
4.	75	125	175	275	300	425	600	Mechanical hand lock
5.	open – 17 closed – 8	open – 30	open – 22¾ closed – 13¾	open – 32 closed – 18	open – 30 closed – 18	open – 49 closed – 25	See Ft. note 1	–
6.	60	60	80	110	120	200	275	–
7.	10 (Dia. round)	10 x 14	13 x 20	16 x 25	19 x 27	26 x 38	29½ x 40	–
8. a.	4	3	4	5	HA – 5¼ HB – 8	6	Up to 60	–
b.	9	15	9	14¼	HA – 12¾ HB – 15	24½	Up to 60	–
9.	25	45	80	120	160	200	400	–
10. a.	–	–	–	–	–	–	–	–
b.	–	–	–	–	–	–	–	–
11.	–	–	7.2	14.3	10.7	28.4	35.4	–
12.	–	–	–	–	–	–	–	–
13.	22,500	20,000	23,000	23,000	23,400	23,200	21,100	5700
14.	2½	4	5	5	8	5	–	ca. 30
15.	15	30	20	30	30	60	75	Hand-operated
16.	Fully Automatic						Fully auto. optional	Manual
17. a.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	–
b.	No	No	No	Optional				–
c.	Yes	Optional						–
18.	15,000	18,000	16,500	27,000	HA – 25,000 HB – 27,000	40,000	60,000	595[2]
19.	–	–	–	–	–	–	–	4-5

IMPROVED MACHINERY: [1]Depends on size and clamp stroke.
BRITISH MACHINES: [2]F.O.B. New York.

INJECTION MOLDING MACHINES

	VAN DORN IRON WORKS CO., CLEVELAND, OHIO				DE MATTIA MACHINE & TOOL CO. CLIFTON, N. J.		
1. Model No.	H-200-2 oz.	H-250-2½ H-260-2½	H-300-3	H-400-4-6	4 oz. G3 Vertical	4-6 oz. K2 Horizontal	12-16 oz. M1 Horizontal
2. Oz. of GP Ps molded per shot	2 (acetate)	2½ (acetate)	3 (styrene)	4 (styrene) 6 (multiple stroke)	4	4-6	12-16
3. Cu. in. molded per shot	–	–	4.85	6.50	6.3	9.4	25.2
4. Locking force, tons	30	30	80	175	128	150	400
5. Max. daylight opening, in.	8½	8½	12	16	19	20	32
6. Plasticating capacity, lb./hr.	12	H-250 – 20 H-260 – 30	75	100	70	100	150
7. Maximum mold size, H x V, in.	8⅞ x 12	8⅞ x 12	16 x 9⅞	13⅜ x 23½	14 x 23	H – 14 x 20 V – 12 x 22	H – 20 x 30 V – 16 x 32
8. Mold clamping stroke a. Min., in.	6	6	4	4	7	Adjustable as required	
b. Max., in.	6	6	8 (Std.) 12(Optional)	10 12(Optional)	15	12	24
9. Rated casting area, sq. in.	20	20	45	75	45 (Approx.)	50 (Approx.)	135 (Approx.)
10. Inj. plunger stroke a. Max., in.	7	7	6½	7	7¼	7¾	11½
b. Min., in.	7	7	6½	7	–	–	–
11. Max. injection speed	225 in./min.	270 in./min.	300 in./min.	245 in./min.	3.1 in./sec. Dry run	6.03 in./sec.	11.5 in./sec.
12. Max. inj. rate at 15,000 p.s.i., cu. in./sec.	–	–	–	–	2.7 Full pressure	10.4	10.5
13. Top ram pressure, p.s.i.	10,000	12,000	15,000	20,000	20,500 On powder	20,250	22,500
14. Min. dry cycle time, sec.	–	720 cycles/hr.	1200 cycles/hr.	840 cycles/hr.	10	6	5
15. Motor, hp.	5	7½	15	20	20	20	30
16. Degree of automation	Semi-auto. or lever operated	Fully automatic			Semi-automatic	Fully automatic	
17. a. Are molds protected against closing on obstruction?	No	Yes	Optional		No	Yes	Yes
b. Is weigh feeder included?	No	No	Optional		No	No	No
c. Are precompressed molding features included?	No	No	Optional		No	No	No
18. Approx. price range, $	Semi – 3600 Lever – 5000	H-250 – 6400 H-260 – 6850	10,500	16,500	18,000[1]	16,500	29,400
19. Approx. delivery time, weeks	4-8	4-8	4-8	4-8	6 months on special order	4-6	4-6

DE MATTIA: [1] Built on special order. If from 4 to 6 of the G3 machines are ordered at once, price will be reduced to $15,000 range.

	NATIONAL AUTOMATIC TOOL CO., INC., RICHMOND, IND.			MOSLO MACHINERY CO., CLEVELAND, OHIO					
1.	300	400, 400X, and 400S	800 and 800X	74-7-2	74-12-2	Duplimatic 11	75-8-4/6 75-15-4/6	76-8-4/6	Duplimatic 12
2.	22	28	80	2	2	3	6	6	6
3.	36.2	46.2	132	3.3	3.3	4.9	9.8	9.8	9.8
4.	325	400 & 400X – 425 400S – 550	850	60	50	75	75-8: 135 75-15: 125	135	90
5.	32 (with spacer) 42½ (spacer removed)	400 & 400X – 38 (with spacer); 50 (without) 400S–36 (with); 48 (without)	55 (with spacers); 85 (spacers removed)	19	24	9	75-8: 23 75-15: 30	23	16
6.	130	165	350	50	50	50	70	90	70
7.	33 x 21¼	38 x 24¾	55 x 36¼	12 x 9	12 x 9	Special mold	18 x 12	18 x 12	Special mold
8. a.	No minimum			7	5	2½	8	8	5
b.	24	26	40	7	12	2½	75-8: 8 75-15: 15	8	5
9.	Depends upon part and material being used			25	25	20	45	45	40
10. a.	15	15	21	5½	5½	8	8	8	8
b.	No minimum			–	–	–	–	–	–
11.	160 in./min.	400 & 400S – 119 in./min.; 400X – 252 in./min.	800 – 102 in./min.; 800X – 204 in./min.	6.3 in./sec.	6.3 in./sec.	4.5 in./sec.	7.8 in./sec.	9.34 in./sec.	9.34 in./sec.
12.	19 (all rated at 20,000 p.s.i.)	400 & 400S – 19 400X – 40	800 – 33 800X – 67	6.3	6.3	4.5	7.8	9.34	9.34
13.	30,000	30,000	30,000	16,550	16,550	17,550	20,000	20,000	20,000
14.	Not rated			2.5	2.5	8	5.5	4.6	5.2
15.	47½	400 & 400S – 47½ 400X – 87½	800 – 82½ 800X – 157½	7½	7½	5	10	15	15
16.	Semi-automatic (See Footnote below)			Fully automatic		Semi-automatic	Fully auto.		Semi-automatic
17.a.	Optional extra (See Footnote below)			Yes	Yes	Optional	Yes	Yes	Optional
b.	Yes	Yes	Yes	No	No	No	No	No	No
c.	No	No	No	No	No	No	No	No	Optional
18.	Prices upon request			10,450	11,365	11,375	14,965 16,330	16,975	16,825
19.	Built in stock quantities for prompt delivery.			3-5	3-5	2-4	3-5 4-6	6-10	8-12

NATIONAL AUTOMATIC TOOL CO.: Machines can be provided with full automatic operation, including low pressure mold protection. Models 800 and 800X can be provided with 55 in. of clamping stroke instead of 40 inches.

LESTER ENGINEERING CO., CLEVELAND, OHIO

1. Model No.	L-2-4/6 L-2B-4/6 L-2C-4/6	L-225-6/9	L-2A-8	L-2-12	L-2-20	L-450-24/32	L-3½-60
2. Oz. of GP Ps molded per shot	4	6	8	12	20	24	60
3. Cu. in molded per shot	–	–	–	–	–	–	–
4. Locking force, tons	150	225	300	400	600	450	750
5. Max. daylight opening, in.	21	38	26	28	35	60	43
6. Plasticating capacity, lb./hr.	–	– –	–	–	–	–	–
7. Maximum mold size, H x V, in.	12¼ x 14	20 x 29⅜ or 27½ x 16½	28 x 22⅛	28 x 24	40 x 28	38 x 27	50 x 29
8. Mold clamping stroke a. Min., in.	6	8	10	12	14	8	16¼
b. Max., in.	9	16	10	12	14	30	16¼
9. Rated casting area, sq. in.	–	–	–	–	–	–	–
10. Inj. plunger stroke a. Max., in.	6⅝	7½	10	14	13⅛	7½	16
b. Min., in.	6⅝	7½	10	14	13⅛	7½	16
11. Max. injection speed, in./sec.	L-2: 7.8 L-2B: 11.3 L-2C: 15.6	26.2	12	12	17.6	48	19.2
12. Max. inj. rate at 15,000 p.s.i., cu. in./sec.	L-2: 10.0 L-2B: 14.5 L-2C: 20.0	33.7	15.4	15.4	24.8	62.7	30.8
13. Top ram pressure, p.s.i.	20,000	20,000	20,000	20,000	21,000	20,000	24,000
14. Min. dry cycle time, sec.	L-2: 6 L-2B: 4.7 L-2C: 3.5	4.2	8.8	12	13.8	7¼	18
15. Motor, hp.	L-2: 20 L-2B: 25 L-2C: 40	30	30	30	50	50	50
16. Degree of automation	Fully automatic		Semi-automatic		Fully automatic		
17. a. Are molds protected against closing on obstruction?	Yes	Yes	Optional	Optional	Optional	Yes	Optional
b. Is weigh feeder included?	Optional	Optional	Optional	Optional	Optional	Optional	Optional
c. Are precompressed molding features included?	No	No	No	No	No	No	No
18. Approx. price range, $	L-2: 14,700-15,700 L-2B: 16,500-17,500 L-2C: 18,000-18,900	24,500 to 25,300	25,300 to 26,200	27,400 to 28,300	43,000 to 44,000	–	62,000 to 63,400
19. Approx. delivery time, weeks	–	–	–	–	–	–	–

LESTER: All of the above standard models can be supplied with a dozen or more auxiliary circuits to fit individual customer requirements. Higher shot pressures, higher cycling and shot speeds, special pressure controls are just some of the auxiliary items that can be put on the machine.

HYDRAULIC PRESS MFG. CO., MT. GILEAD, OHIO

1.	200-H-6/8A	350-HV-12/16	450-HV-20/28	650-HV-32/42	100-HV-48/64	200P28	450P80	650P140	1000P-200	1500P-300
2.	6-8	12-16	20-28	32-42	48-64	28	80	140	200	300
3.	10	20	34	54	81	49	140	239	350	600
4.	200	350	450	650	1000	200	450	650	1000	1500
5.	With ejector 25 Without ejector 29	34 42	40 48	50 58	65 79	25 29.	40 or 54 48 or 62	50 58	65 79	106 120
6.	90	150	200	300	300	90	200	300	300	400
7.	26 x 15 15 x 26	20 x 34 34 x 20	26½ x 36 20½ x 42	30 x 48 48 x 30	39 x 60 60 x 39	15 x 26 26 x 15	26½ x 36 20½ x 42	30 x 48 48 x 30	60 x 39 39 x 60	48 x 72 72 x 48
8. a.	Not limited									
b.	15	22	25	30	45	15	25 or 34	30	45	60
9.	Not limited with hydraulic clamp									
10. a.	10	12	12	15	18	10	12	15	18	18
b.	Not limited									
11.	22[1]	41.4[1]	47.2[1]	84.8[1]	124.5[1]	–	–	–	–	–
12.	11.25 or 22.5	20.5 or 35.5	24.3 or 39.3 or 46.8	41.8 or 56.8 or 64.3	65.3 or 87.8	22.5	24.3 or 39.3 or 46.8	41.8 or 56.8 or 64.3	65.3 or 87.8	111.0
	NOTE: At 20,000 p.s.i.									
13.[2]	3000	3000	3000	3000	3000	3000	3000	3000	3000	2610
14.	4.0	3.6	7.8	9.9	–	–	–	–	–	–
15.	30 or 50	60 or 90	75 or 105 or	107½ or 137½ or 157½	180 or 235	50	75 or 105 or 125 or 175	107½ or 137½ or 1157½	180 or 235	275
16.	Semi-automatic—Fully automatic optional									
17.a.	Optional									
b.	Optional	Optional	Yes	Yes	Yes	Not required				
c.	Optional	Optional	Optional	Optional	Optional	Not required				
18.	20,000	30,000	40,000	55,000	80,000	29,000	53,000	74,000	100,000	140,000
19.	Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock

[1] in./sec. (prepositioning); [2] Top *hydraulic* ram pressure

NEWBURY INDUSTRIES, INC., NEWBURY, OHIO

1. Model No.	Air mini-matic 60 AM 80	Air jet 55 and air bench 45	Standard 50 and special 50	Standard super hornet	60 PC100 super hornet	Eldorado and super eldorado
2. Oz. of GP Ps molded per shot	¾	¾	Standard - ¾ special - 1	¾	1	Up to 1½ (vinyl)
3. Cu. in. molded per shot	1.5	1.5	Standard - 1.5 special - 2	1.5	2	3
4. Locking force, tons	10	Wedge principle	Wedge principle	12	12	18
5. Max. daylight opening, in.	3½	Open manually	Open manually	3½	3½	4⅞
6. Plasticating capacity, lb./hr.	5.5	5.5	Standard - 5.5 special - 7.5	5.5	7.5	7.5
7. Maximum mold size, H x V, in.	5 x 6 x 5⅛	2 1/16 x 2⅝ x 4½ 2 1/16 x 2⅝ x 6	2 1/16 x 2⅝ x 4½ 2 1/16 x 2⅝ x 6	5 x 6 (H) x 5⅛ (V)		
8. Mold clamping stroke a. Min., in.	2½	–	–	2½	2½	3½
b. Max., in.	3	–	–	3	3	4
9. Rated casting area, sq. in.	6	6	6	6	6	8
10. Inj. plunger stroke a. Max., in.	6	6	6	6	6	8
b. Min., in.	1	1	1	1	1	1
11. Max. injection speed, cu. in./sec.	1.5[1]	1.5[1]	1.5	1.5	1.5	Eldorado - 1.5 super - 2.5
12. Max. inj. rate at 15,000 p.s.i., cu. in./sec.	.75	.75	.75	.75	.75	Eldorado - 7.5 super - 1.25
13. Top ram pressure, p.s.i.	¾" ram 6400	¾" ram 6400	Standard-8600 special - (1" dia. ram) 6300	¾" ram 8600	⅞" ram 6300 at 1200 # oil	1 1/16" ram 4425 at 1200 # oil
14. Min. dry cycle time, sec.	6	10	10	7	7	Eldorado - 7 super - 6
15. Motor, hp.	Air operated		Standard - 1 special - 2	1	2	2
16. Degree of automation[2]	F.A.	M.O.	M.O.	M.O.	M.O.	Eldorado-M.O. super - S.A.
17. a. Are molds protected against closing on obstruction?	Yes	–	–	No	No	Eldorado-No super - Yes
b. Is weigh feeder included?	No	No	–	No	No	No
c. Are precompressed molding features included?	Yes	Manually Yes	Manually Yes	Manually Yes	Manually Yes	Manually - Yes Super - Yes
18. Approx. price range, $	3000	Air jet - 2000 air bench - 950	Standard - 1700 special - 1800	2400	2500	Eldorado - 3400 super - 5000
19. Approx. delivery time, weeks	3 - 6	Air jet - 2 to 3 air bench - 1 to 2	2 to 3	2 to 3	2 to 3	Eldorado - 2 to 4 super - 2 to 6

[1] Depending on air supply and valve setting; [2] M.O. - Manually operated; S.A. - Semi-automatic; F.A. - Fully automatic

WATSON-STILLMAN PRESS., DIV. FARREL-BIRMINGHAM CO., INC., ROCHESTER, N.Y.

1. Model No.	5ES-215	10ES-300	16ES-400-s	24ES-425	32ES-650	48ES-1000
2. Oz. of GP Ps molded per shot	5	10	16	24	32	48
3. Cu. in. molded per shot	6½	13	22	33	42	62
4. Locking force, tons	215	300	400	425	650	1000
5. Max. daylight opening, in.	30 24 (with spacer)	30	34	40	54 (without spacer) 42 (with spacer)	66 (without spacer) 48 (with spacer)
6. Plasticating capacity, lb./hr.	80	140	150	250	300	500
7. Maximum mold size, H x V and V x H	15¾ x 25½	20½ x 36	20 x 36 & 21 x 33	27 x 45 & 25 x 40½	27 x 45 & 27 x 43½	40 x 60
8. Mold clamping stroke: **a. Minimum, in.**	Full hydraulic machine, from zero to maximum					
b. Maximum, in.	12	18	16	24	30	36
9. Rated casting area, sq. in.	107	150	200	212	325	500
10. Injection plunger stroke: **a. Maximum, in.**	9	12	12	14½	14½	18½
b. Minimum, in.	5½	6	6	7¼	7¼	9¼
11. Max. injection speed, in./min.	270	210	195	174	130	200
12. Max. inj. rate at 20,000 p.s.i., cu. in./min.	1000	1240	1620 22,500 p.s.i.	1795	3000	7000 21,000 p.s.i.
13. Maximum pressure on material, p.s.i.	20,000	20,000	22,500	20,000	20,000	21,000
14. Min. dry cycle time, sec.	6	6½	7½	9	10	12
15. Motor^a, hp.	50	50	65	70	70	135
16. Degree of automation[1]	M.O. S.A. F.A.	M.O. S.A. F.A.	M.O. S.A.	M.O. S.A.	M.O. S.A.	M.O. S.A.
17. Are molds protected against closing on obstruction?	Yes, by low pressure die closing feature		Optional: by low pressure die closing feature			
18. Weigh feeder included?	No (optional)	No (optional)	No (optional)	No (optional)	No (optional)	No (optional)
19. Precompressed molding features included?	No (optional)	No (optional)	No (optional)	No (optional)	No (optional)	No (optional)

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[1] M.O. — Manually operated; S.A. — Semi-automatic; F.A. — Fully automatic.

The following models can be equipped, and are offered, with preplasticizing units that increase max. shot capacity. They then have new model designations as follows: Model 5ES-215 with preplasticizing unit (max. shot capacity to 15 oz. — styrene) is designated PE15-215; Model 10ES-300 with preplasticizing unit (max. to 30 oz. — styrene) designated PE30-500; Model 16ES-400S with preplasticizing unit (max. to 48 oz. — styrene) designated PE48-400S; Model 24ES-425 with preplasticizing unit (max. to 64 oz. — styrene) designated PE64-425; Model 32ES-650 with preplasticizing unit (max. to 100 oz. — styrene) designated PE100-650; Model 48ES-1000 with preplasticizing unit (max. to 175 oz. — styrene) designated PE175-1000.

The 24-oz. machine is also offered with a 650-ton clamp and is designated Model 24ES-650; with preplasticizer, Model PE64-650.

COVEMA, s.r.l., MILAN, ITALY

1. Model No.	Plastiniector V 55	Plastiniector V 111	Plastiniector V 175	Plastiniector V 308	Plastiniector V 504	Plastiniector V 1200
2. Oz. of GP Ps molded per shot	2 (59g.)	4 (120g.)	7 (189g.)	12 (332g.)	19 (544g.)	47 (1320g.)
3. CM^3 molded per shot	55	111	175	308	504	1200
4. Locking force, tons	35	65	102	195	270	517
5. Max. daylight opening, in.	14	16	17¾	25⅝	27⅝	39⅜
6. Plasticating capacity, kg./hr.	9.4	14.4	22.6	39.8	65.2	120
7. Maximum mold size, H x V, min.	360 x 300	450 x 390	550 x 500	660 x 600	710 x 630	770 x 950
8. Mold clamping stroke: Max. & Min., in.	12	14	16	21 11/16	24	29 9/16
9. Rated casting area, cm^2	134	250	350	650	900	–
10. Max. injection plunger stroke, in.	2⅜	2⅜	2⅜	3⅛	4	5
11. Min. injection plunger stroke, in.	1⅝	3	4⅝	4⅝	7 7/16	8
12. Max. injection speed	2.1 sec.	2.6 sec.	3 sec.	3.3 sec.	4 sec.	6.3 sec.
13. Min. dry cycle time, sec.	10-90	10-90	15-180	20-180	20-180	–
14. Motor[a], hp. a. Power of motor pump	5	8	10	15	20	32
b. Power of screw motor	1.5	1.5	1.5	2.5	2.5	5
15. Degree of automation	Fully automatic					
16. Are molds protected against closing on obstruction?	Yes, on request					
17. Approx. price range, $	3838	5849	8117	11,531	15,560	37,314
18. Approx. delivery time, days	80/90	80/90	90/120	90/120	120/150	120/150

NEGRI BOSSI & CO., MILAN, ITALY

1. Model No.	R.3/FA	R.6/FA	R.12/FA	NB 60 E	NB 220 E	NB 360/520 E
2. Oz. of GP PS molded per shot	$1\frac{1}{6}$	2 - 3	4 - 6	2.1	8	13 - 19
3. Cu. in. molded per shot	1.71	3.42	6.84	3.42	18.6	20.5
4. Locking force, tons	25	60	114	60	228	150 to 300
5. Max daylight opening, in.	15.5	18.5	23.6	18.5	26.7	29.5
6. Plasticating capacity, lb./hr.	12	29	53	28.6	75	97
7. Maximum mold size, H & V Vertical Horizontal	8.6 x 9 —	12.6 x 13.3 19.6 x 6.3	14.1 x 17.7 22.8 x 9	12.6 x 13.3 19.6 x 6.3	16.1 x 22.8 26.7 x 12.2	17 x 28.7 15.1 x 30.7
8. Max. mold clamping stroke, in.	6.9	12.6	15.7	12.6	18.8	21.6
9. Rated casting area, sq. in.	12.7	28.6	54.2	28.7	108.5	142.6
10. Max. injection plunger stroke, in.	5.2	5.9	8	5.9	9.8	11.8
11. Max. injection speed, cu. in./sec.	1.4	3.4	4.6	3.4	6.4	9.8
12. Top ram pressure, p.s.i.	17,400	18,920	18,400	18,910	20,765	21,334
13. Min. dry cycle time, sec.	5	7.5	7.5	15	15	20
14. Motor, hp.	6	10	15	7.5	22	35
15. Degree of automation	Fully automatic					
16. Are molds protected against closing on obstruction?	Yes	Yes	Yes	No	No	No
17. Weigh feeder included?	Optional	Optional	Optional	No	No	No
18. Precompressed molding features included?	No	Yes	Yes	No	No	Yes

PECO MACHINERY SALES (WESTMINSTER) LTD., LONDON, S.W.1

1. Model No.	40.MP.50.	50.MP.60.	60.MP.60.	30.MS.30.	30.MP.40.	40.MS.40.
2. Oz. of GP PS molded per shot	29	60	60	4.5	9	12 Single feed 16 double feed
3. Cu. in. molded per shot	59	110	110	7.4	19.5	20 Single feed 26.6 double feed
4. Locking force, tons	300	500	750	150	150	300
5. Max. daylight opening, in.	35½	48	67	24¾	24¾	35½
6. Plasticating capacity, lb./hr.	150	200	200	90	90	110
7. Maximum mold size, H & V, in.	30 x 32	36 x 42	54 x 56	25 x 23.5	25 x 23.5	30 x 32
8. Min. mold clamping stroke, in.	12½	16	21	7½	7½	12½
9. Max. mold clamping stroke, in.	17½	23	32	12	12	17½
10. Rated casting area, sq. in.	300	500	435	60	100	134
11. Max. injection plunger stroke, in.	4.75	6	6	10.37	3	10
12. Max. injection speed, cu. in./sec.	27	33.5	33.5	7.5	13.6	16.3
13. Max. inj. rate at 15,000 p.s.i., cu. in./sec.	–	–	–	10	9.2	–
14. Top ram pressure, p.s.i.	11,000	11,680	11,680	21,000	15,000	18,800
15. Min. dry cycle time, sec.	15	25	25	6	10	10
16. Motor, hp.	35	50	50	15	15	35
17. Degree of automation	Fully automatic	Semi-automatic		Fully automatic		
18. Are molds protected against closing on obstruction?	Yes	No	No	Yes	Yes	Yes
19. Weigh feeder included?	No	No	No	No	No	No

A. TRIULZI, s.a.s., MILAN, ITALY

1. Model No.	Plastmatic 14/P80	Plastmatic 35/P80	Plastmatic 80/P80	Plastmatic 400/P100	Plastmatic 1500/P160	Plastmatic – oil 2200/P2 x 120
2. Oz. of GP PS molded per shot	9	27	55	140	425	700
3. Cu. in. molded per shot	14	43	87	235	697	1160
4. Locking force, tons	135	310	450	1100	1650	2400
5. Max. daylight opening at open platens, in.	24	28	46	56	98½	98½
6. Plasticating capacity, lb./hr.	44	99½	154	220	440	551
7. Maximum mold size, H x V, in.	19¼ x 34	17¼ x 28	19¼ x 34	36½ x 57¾	51¼ x 72¾	51¼ x 72¾
8. Min. mold clamping stroke, in.	0	0	0	0	0	0
9. Max. mold clamping stroke, in.	12	20	28	28	59	59
10. Rated casting area, sq. in.	93	217	310	775	1160	1710
11. Max. injection plunger stroke, in.	9⅝	10	12	23	23	23
12. Min. injection plunger stroke, in.	0	0	0	0	0	0
13. Max. injection speed, cu. in./sec.	14	35	67	59	116	165
14. Max. inj. rate at 15,000 p.s.i., cu. in./sec.	9	26	55	140	425	700
15. Top ram pressure, p.s.i.	2000	2000	2000	2000	2000	2000
16. Min. dry cycle time, sec.	5	6	10	20	22	23
17. Motor, hp.	32	51	86	140	180	200
18. Degree of automation	Fully automatic, cycle					
19. Precompressed molding features included?	Optional	Optional	Optional	Optional	Optional	Optional
20. Approx. delivery time, days	60/120	60/120	90/120	120/150	120/150	120/150

ADDITIONAL INFORMATION: Water-hydraulic operated injection molding machines from ¾ to 700 oz. available. Standard equipment: control lever device; but can be equipped with automatic cycling equipment. Machines 32 oz. and over already equipped with automatic cycling equipment.

Oil-hydraulic operated machines available from ¾ oz. to 700 oz. Machines up to 6 oz. can be supplied with hand control through lever device or with fully automatic operation.

Clamping systems can either be an "H" toggle, a piston lock, or a special hydro-mechanical unit.

The 6 models described above are automatic oil-hydraulic machines with preplasticizers. Vertical injection molding machines and a special simultaneous two-color molding machine also available.

INJECTION MOLDING MACHINES	Dowding & Doll, Ltd., London, W. 14, England			R. H. WINDSOR LTD., CHESSINGTON, SURREY, ENGLAND					
Model No.	Dowding Automatic	Westminster (hand oper.)	Westminster (power oper.)	AP 16	AP 1044	AP 20/115	AP 130	AP 200	AP 335
Oz. of GP PS molded per shot	1	1/3	1/2	14	26	67	80	124	210
Cu. in. molded per shot	1.6	–	–	16	44	115	130	200	335
Locking force, tons (English)	–	–	–	175	300	500	800	800	1100
Daylight opening stroke, in.	8-7/8	6-1/2	6-1/4	24	29	37	68	68	86
Plasticating capacity, lb./hr.	20	2	6	100	120/140	250/300	250/300	350	420
Max. mold size, H x V	9 x 10	6-3/8 x 8	6-3/8 x 8	23 x 23	29 x 25	38 x 34	51 x 51	51 x 51	62 x 70
Max. mold clamping stroke, in.	–	–	–	10 (constant)	12	17	36	36	42
Min. mold height, in.	3-3/8	Special locking bolster	1-1/8	–	–	–	–	–	–
Max. mold height, in.	7-1/4	–	5-1/8	–	–	–	–	–	–
Rated casting area, sq. in.	15	5	9	90	160	300	450	–	–
Injection plunger stroke, in., max.	2	3	3	–	–	–	–	17	17
min.	1/8	–	–	–	–	–	–	–	–
Ram pressure, lb.	18,850	–	7000	–	–	–	–	–	–
Top ram pressure, p.s.i.	9100	–	9000	12,500	10,000	10,000	10,000	12,500	12,500
Min. dry cycle time, sec.	3	–	–	–	–	–	–	–	–
Motor, hp.	7	hand-operated	3	20	25	50	50	50 + 50	150 + 25
Degree of automation	Fully automatic	Manually operated	Semi-automatic	Fully automatic			Fully automatic		
Are molds protected against closing on obstruction?	Yes	No	No	Yes	No	No	–	–	–
Is weigh feeder included?	No	No	No	No	No	No	–	–	–
Are precompressed molding features included?	No	No	No	No	No	No	–	–	–
Approx. price range	–	–	–	–	–	–	–	–	–
Approx. delivery time, wks.	8	Ex. stock	Ex. stock	18	30	30	12	12	18

DAKE CORP., GRAND HAVEN, MICH.

Model No.	43-101(S)	43-103(S)	43-105(S)	27-200(S)	27-201(S)	27-202(S)	27-204(S)	27-206(S)	27-208(S)
Pressing capacity, tons: Compression	75	150	300	25	50	75	150	300	500
Transfer	25	50	75	–	–	–	–	–	–
Hydraulic line pressure, p.s.i.	5300	6000	5800	4900	5100	5300	6000	5800	4800
Max. mold dimensions, L x W, in.	18 x 28	25 x 32	36 x 45	22 x 25	29 x 30	35 x 40	48 x 60	55 x 60	74 x 70
Max. stroke, in.	14	20	24	14	14	14	20	24	28
Drive, hp.	10	15	25	7½	7½	15	25	30	75
No. of platens	Transfer type presses are all single opening; multiple platens optional								
Daylight opening, in.	22	32	40	20	20	22	32	40	46
Max. closing speed, in./min.	240	285	190	410	340	455	425	350	210
Pressing speed, Max., in./min.:	30	17	8	80	42	30	17	17	7
Min., in./min.:	Variable speeds optional on main rams, standard on transfer rams			1	1	1	1	1	1
Max. opening speed, in./min.	360	330	330	850	530	680	490	490	230
Floor space, L x W, in.	28 x 31	33 x 38	33 x 38	34 x 17½	41 x 23	51 x 28½	72 x 39½	80 x 42½	100 x 59

Dake transfer type presses are equipped with two pairs of dual palm push buttons for controlling the main ram and the transfer ram. A preset cycle is carried out. Breathing and ejection features are available on all models. Heated or heated and cooled platens are available for all models; they can be either electrically or steam heated and water cooled. Indicating thermostats can be supplied to suit particular requirements. The strokes, bed sizes, daylights, and speeds can be increased or decreased to suit. The electrical controls meet J.I.C. standards.

Models above indicate only various series available; on all models, other sizes available up to 600 tons.

THE FRENCH OIL MACHINERY CO., PIQUA, OHIO

Pressing capacity, tons: Compression	100	150	200	250	300	350	400	450	500
Transfer	30	51	67	82	100	115	136	150	168
Hydraulic line pressure, p.s.i.	2540	2490	2510	2490	2500	2480	2490	2480	2490
Max. stroke, in.	16	16	16	16	18	18	18	18	18
Drive, hp.	7½	10	15	20	20	25	25	25	30
Daylight opening, in.	34	34	34	34	36	36	36	36	36
Max. closing speed, in./min.	400	400	400	400	400	400	400	400	400
Max. pressing speed, in./min.	8.8	8.8	8.1	8.6	9.1	8.7	8.6	8.6	8.4
Max. opening speed, in./min.	174	176	162	173	183	173	174	173	170

COMPRESSION MOLDING MACHINES

	RODGERS HYDRAULIC, INC., MINNEAPOLIS, MINN.			F. J. STOKES CORP., PHILADELPHIA, PA.				
Model No.	TCMA-150-2420-20	TCMA-200-3024-10	TCMA-300-3630-10	800	741	741-T	726	726
Pressing capacity, tons: Compression	150	200	300	15 or 25	50 or 75	150	50	300
Transfer	32	40	60	–	–	30	19	70
Hydraulic line pressure, p.s.i.	5000 maximum			Air 100	2750	2750	3000	3000
Max. mold dimensions, L x W x H, in.	22x18x28	28x22x28	34x28x32	10x6x15¾	15x13x18	24x20x20	18 x 16	36 x 32
Max. stroke, in.	24	24	24	5	12	14	12	18
Drive, hp.	20	20	30	2	7½	10	5	15
No. of platens	2	2	2	2	2	2	2	2
Daylight opening, in.	38	38	42	12-15¾	28	32	28	48
Air pressure required, p.s.i.	85	85	85	100	60	60	–	–
Max. closing speed	435 in./min.	468 in./min.	456 in./min.	600 in./min.	300 in./min.	400 in./min.	350 in./min.	250 in./min.
Pressing speed: Maximum:	31 in./min.			10 in./min.	27 in./min.	22 in./min.	20 in./min.	10 in./min.
Minimum:	Variable			1 in./min.	½ in./min.	½ in./min.	¼ in./min.	¼ in./min.
Max. opening speed	325 in./min.	360 in./min.	360 in./min.	600 in./min.	300 in./min.	400 in./min.	290 in./min.	245 in./min.
Cycle controls:	Fully automatic; semi-auto.; manual			Sequence control-fully automatic			Bar control automatic	
Breathing	Yes	Yes	Yes	Optional	Yes	Yes	Yes	Yes
Ejection	Hyd. Top and bot. stand.	Hyd.	Hyd.	Bot.-stand. top.-opt.	Bottom and top			
Heating and cooling of platens: Type of heater:	Electric			Electric or steam heat				
Method of control:	Indicating controller			Thermostats		Indicating pyrometers		
Attachments and auxiliaries available	Insulated platens; oil cooler; automatic unloader; air-operated hold-down — std. equipment			Breathe top eject. ind. pyro.	Indicating pyrometer Integral preheater		Hydraulic ejectors bot. or top transfer	
Other automation features:	Auto. preform preheater Auto. powder preheater			Fully automatic standard			–	–
Floor space, L x W, in.	120 x 101	128 x 115	136 x 124	21½ x 62	45 x 118	47 x 125	68 x 48	105 x 60

PASADENA HYDRAULICS, INC., EL MONTE, CALIF.

Model No.	P	PW	Q & B	TP 30-10	TP 50-20	TP 125-50	Q & B	H8	K 10
Pressing capacity, tons: Compression	20	20	30 or 50	30	50	125	30 or 50	70	125
Transfer	–	–	–	10	20	50	–	–	–
Hydraulic line pressure, p.s.i.	3200	3200	3200	4000	4000	4000	3200 & 3500	3500	3750
Max. mold dimensions, L x W x H, in.	8 x 8 x 8	12 x 9 x 8	12x12x8	12x12x6	12x12x8	18x18x12	12x18x8	18x18x12	24 x 24
Max. stroke, in.	4	4	4	6	8	12	4 & 6	8	12
Drive, hp.	MANUAL			1½	1½	3	¾	1½	3
No. of platens	2 or more			2	2	2	2 or more		
Daylight opening, in.	8	8	8	6	8	12	8 & 10	12	15
Max. demand of electric power, kw.	1½	3	4	6	6	18	6	8	16
Max. closing speed, in./sec.	Two stage manual pump			50-200	72-200	64-200	50	72	64
Pressing speed: Max., in./sec.	–	–	–	10	10	10	10	10	10
Min., in./sec.	–	–	–	½	½	½	1	1	1
Max. opening speed, in./sec.	Gravity return			200	200	200	Gravity return		
Floor space, L x W, in.	12 x 19		14 x 19	16 x 28	30 x 30	28 x 36	14 x 25	24 x 24	28 x 37

Models P, PW, Q & B, H8, and K 10 available with steam or electric heating of platens. Steam platens have drilled passages; electric versions have cast-in Calrod heaters and cooling coils. Models TP 30-10, 50-20, and 125-50 heated electrically with Calrod units. On all units, heating is controlled with thermoswitches. Cooling medium on all models is water. For TP models, cycle controls can be manual or automatic; for Q & B, H8, and K 10 models, cycle controls can be manual, semi-automatic, or fully automatic. On the three latter models, program cycling, if required, is available. Bench model presses are complete with all controls required. Manual pump is a patented feature that gives quick closing and maximum pressure.

ERIE ENGINE AND MFG. CO., ERIE, PA.

Pressing capacity, tons: Compression	50	100	200	300	500	750	1000
Transfer	15	20	40	75	125	200	250
Hydraulic line pressure, p.s.i.	2500	2500	2500	2500	2500	2500	2500
Max. mold dimensions, W x L, in.	18 x 16	24 x 18	30 x 24	36 x 30	42 x 36	66 x 42	72 x 48
Drive, hp.	7½	10	15	40	50	60	75
Max. closing speed, in./sec.	10	10	10	10	10	7.5	5
Pressing speed, in./sec.: Maximum	VARIABLE						
Minimum	1/32	1/32	1/32	1/32	1/32	1/32	1/32
Max. opening speed, in./sec.	7.5	7.5	7.5	7.5	7.5	5	4
Floor space, L x W, in.	48 x 30	66 x 42	72 x 42	78 x 60	126 x 72	156 x 78	180 x 96

Variable daylight openings and maximum pressing speeds available on all models. Cycle controls on all models are semi-automatic with breathing and ejection feature available. Heating of platens is by steam or electricity; cooling is by water. Controls for both heating and cooling to customer specifications. Special presses up to 5000 ton capacity will be designed to customer specifications on request.

WILLIAMS-WHITE AND CO., MOLINE, ILL.

Pressing capacity, tons: Compression	50	100	150	200	300	500
Transfer	12½	25	35	50	75	125
Hydraulic line pressure, p.s.i.	2700 or less			2700 or less		
Max. mold dimensions, L x W x H, in.	16 x 16	24 x 20	24 x 24	30 x 24	36 x 30	42 x 36
Max. stroke, in.	14	16	18	20	24	30
Drive, hp.	5	10	15	20	25	35
No. of platens	2	2	2	2	2	2
Daylight opening, in.	24	30	32	36	44	54
Max. closing speed, in./min.	Approx. 300			Approx. 300		
Max. opening speed, in./min.	Approx. 200			Approx. 200		
Floor space, L x W, in.	84 x 60	96 x 66	102 x 66	108 x 72	114 x 78	126 x 96

On all models: pressing speeds to order; semi-automatic cycle controls (special features and designs to fill customer requirements) with ejection controls available; steam or electric heating, automatically controlled; water cooling automatically controlled. NOTE: All the presses listed above are representative of range of manufacture; special presses, both laboratory and production models, can be built to order.

ELMES ENGINEERING DIV., CINCINNATI, OHIO

Model No.	7100	7150	7200	7300	7500	8624	7703
Pressing capacity, tons: Compression	100	150	200	300	500	750	1000
Transfer	25	35	50	75	125	200	250
Max. mold dimensions, L x W, in.	24 x 20	24 x 24	30 x 26	36 x 30	42 x 36	66 x 42	72 x 50
	Left to right by front to back						
Max. stroke, in. (main ram x transfer ram)	12 x 12	12 x 12	15 x 12	18 x 14	24 x 16	30 x 18	36 x 20
Drive, hp.	7½	10	15	20	30	30	30
No. of platens	1	1	1	1	1	1	1
Daylight opening, in.	24	32	36	44	54	60	72
Closing speed, in./min.	285	285	310	300	310	210	165
Pressing speed, in./min.:	18	18	20	15	15	10	7½
Opening speed, in./min.	245	245	240	185	165	135	125
Floor space, L x W, ft.	5½ x 3½	5½ x 3½	6 x 3½	7½ x 5	10½ x 6	12 x 7½	13 x 7½

On all models: semi-automatic cycle controls; breathing features optional; mechanical ejection available; steam or electric heating optional; water cooling automatically or manually controlled. Speeds shown are typical; other speeds available to suit requirements.

	LOGAN HYDRAULICS, INC., CHICAGO, ILL.						DUNNING AND BOSCHERT PRESS CO., INC., SYRACUSE, N.Y.
Model No.	150T	200T	300T	50T	75T	100T	A-3830
Pressing capacity, tons: Compression	150	200	300	50	75	100	15-75 (variable)
Transfer	30	40	60	10	15	20	To order
Hydraulic line pressure, p.s.i.	2500 max.	2500 max./5000 max.		2000 max.			Per requested press pressure
Max. mold dimensions, L x W, in.	26 x 20 Left to right by front to back	30 x 24	36 x 30	16 x 14	18 x 16	24 x 18	12 x 12 to 24 x 24
Max. stroke, in.	C-15 T-12	C-15 T-12	C-18 T-14	C-10 T-8	C-12 T-10	C-12 T-12	12 (Avg.)
Drive, hp.	Aver.-15 variable		Aver.-20 variable	Aver.-7½ variable	Aver.-10 variable		7½-10
No. of platens	Single opening						2-7 (Avg.)
Daylight opening, in.	36 (Adjustable)		42 (Adj.)	18 (Adj.)	24 (Adj.)	30 (Adj.)	2 (Avg.)
Air pressure required, if any, p.s.i.	–	–	–	–	–	–	80 air line pressure for air-oil power
Vol. of air required, cu. ft./min.	–	–	–	–	–	–	Dep. on speed requested
Max. closing speed, in./sec.	7.5 (variable)			4 (variable)		7.5 (var.)	220 in./min. (Avg.)
Pressing speed, in./sec.: Maximum	1 (variable)			¾ (variable)		1 (var.)	10 in./min. (Avg.)
Minimum	0						Adj. speed control to order
Max. opening speed, in./sec.	7.5 (variable)			4 (variable)			250 in./min. plus
Cycle controls	Semi-automatic or manual breathing features optional; ejection-spring/hydraulic						See Ft. Note 1 below
Heating and cooling of platens	Steam/electrical heating; method of heating control optional; cooling optional						See Ft. Note 2 below
Floor space, L x W, in.	Variable						31 x 31[3]
Approx. price range, $	Available on request						Available on request

Ft. Notes: LOGAN HYDRAULICS: All models, by means of various attachments, can be converted to fully automatic operations. NOTE that Logan not only manufactures the presses listed above, but also designs to meet specialized customer requirements.

DUNNING & BOSCHERT: Size and type of hydraulic power units depends on press capacity in tons. Over-all height: 7' 2"; from floor to first platen: 53¾". [1] Electric pushbutton timed cycle control; semi-automatic or repeat cycle. Breathing features and bottom or top ejection optional. [2] Electric or steam heating with thermostat indicating-type control; water cooling controlled manually or automatically. [3] For air-oil powered model.

HULL-STANDARD CORP., HATBORO, PA.

Model No.	250B, 259B, 350B, 359B, 450B, 550B	350D, 359D, console style	99A (Auto. trans. only)	250B, 259B, 350B, 359B, 450B, 550B	250B, 259B, 350B, 359B, 450B, 550B	350C, 359C, 550C	250C, 259C, 350C, 359C, 450C, 550C	250B, 259B, 350B, 359B, 450B, 550B
Pressing capacity, tons: Compression	300	25	15	50	75	100	150	200
Transfer	43-75	7	2	12-19	19	25	19-42.5	29-50
Hydraulic line pressure, p.s.i.	1000-3100	2000	Pneumatic 80 p.s.i. max.	875-3000	850-3000	C-2000 T-2550	1000-3000	1000-3100
Max. mold dimensions, L x W x H, in.	36 x 31 x 26	18 x 18 x 15	7½ x 4½ x 6½	18 x 18¾ x 20	18 x 18¾ x 20	24 x 23 x 20		26 x 26 x 21
Max. stroke, in.	10-18	6	1¾	7-12	7-12	14	8-14	8-15
Drive, hp.	5-20	5	110 v. (single phase)	3-5	3-5	7½-10	5-10	5-15
No. of platens	Single opening							
Daylight opening, in.	44	21	8¼	24-27	24-27	32	32	36
Max. demand of electric power, kw.	100 amp. @ 220 v.	25 amp. @ 220 v.	50 Watts	25 amp. @ 220 v.	35 amp. @ 220 v.	50 amps.		75 amp.
			Plus heater current					
Air pressure required, p.s.i.	60 for auto.	—	80	60 p.s.i. for automatics				
Volume of air required, cu. ft./min.	3/cycle at atmospheric pressure		7/cycle at atmos. pressure	2 cu. ft./cycle, atmospheric pressure				
Max. closing speed, in./sec.	5	3	1	5	5	5	5	5
Pressing speed, Max., in./sec.:	1/5	1/2	1	1/5	1/5	1/5	1/5	1/5
Min., in./sec.:	0	0	1/2	0	0	0	0	0
Max. opening speed, in./sec.	5	3	1	5	5	5	5	5
Cycle controls:	Semi-auto. Fully auto.	Semi-auto. Manual	Fully auto.	Fully automatic and semi-automatic				
Breathing?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Ejection?	Top and bot.	Bot. only	Yes	Top and bottom				
Type of heater:	Electric/steam		Elec.	Electric or steam				
Method of control:	Electric thermostats							
Floor space, L x W, in.	116 x 107 (or less)	27 x 50	24 x 84	82 x 75 (or less) depending on model		94 x 87 (or less) depending on model		102 x 94 (or less)

All models, with exception of 99A and "D" series, available with universal loader; Quickset controls available on all models except 99A.

ATLAS HYDRAULICS DIV., DELAWARE VALLEY MFG. CO., INC., PHILADELPHIA, PA.

Model No.	"100"	125	200	"250"	"300"
Pressing capacity, tons: Compression	20, 30, 40	30 and 50	50 and 75	50, 75, 100, 125, 150, 200, 250, 300	25, 50, 75, 100, 150, 200
Transfer	–	–	–	To Specification	
Max. mold dimensions, L x W, in.	8 x 8, 10 x 10, 12 x 12	10 x 10, 12 x 12	12 x 12, 14 x 14	14 x 14, 16 x 16, 18 x 18, 20 x 20, 24 x 24	
Max. stroke, in.	8	6	6	To Specification	
Drive, hp.	2-Stage hand hydraulic pump	Air-powered hydraulic pump		Depends on closing speed required	
No. of platens	2 or 3	2 or 3	2 or 3	To Specification	
Daylight opening, in.	8	6	6	To Specification	
Air pressure, p.s.i.	–	80	80	–	–
Cycle controls	2-Stage hand hydraulic pump	Manual	Manual or semi-auto.	Manual, pushbutton, or semi-auto.	
Type of heater	Steam, electric, or water			Steam or electric	
Method of control	Thermostats to 600° F.		Indicating or recording type		

Water cooling controlled manually (in Models 100 and 122) or with custom built controls (Models 200, 250, and 300). "T" slotted platens, pull-back cylinder, knock-out pins, and two-speed operation available in Models 250 and 300. Model 200 designed for laboratory laminating or molding; Model 250 for laminating or molding and equipped with ultra-heavy-duty slab-side frame; Model 300 for flexible compression and transfer molding and built with heavy column-bolt frame. Modification to customer requirements on all models. Custom built presses in any size or capacity also available.

THE HYDRAULIC PRESS MFG. CO., MT. GILEAD, OHIO

Model No.	100-C – 100-T	200-C – 200-T	300-C – 300-T	500-C – 500-T
Pressing capacity, tons: Compression	100	200	300	500
Transfer	T-35 C –	T-50 C –	T-80 C –	T-125 C –
Hydraulic line pressure, p.s.i.	2100	2000	2000	2075
Max. mold dimensions, L x W x H, in.	24 x 18	30 x 24	36 x 30	42 x 36
Max. stroke, in.	15	15	18	26
Drive, hp.	C-5 – T-7½	C-7½ – T-10	C-15 – T-20	C-25 – T-45
No. of platens	2	2	2	2
Daylight opening between platens, in.	30	36	54	54
Max.: closing speed, in./sec.	4	3.5	3.4	5.2
opening speed, in./sec.	1.5	1.3	1.6	1.75
Pressing speed: Max., in./sec.	.2	.15	.2	.22
Min., in./sec.	.04	.03	.04	.04
Floor space, L x W, in.	55 x 82	91 x 55	67 x 104	67 x 115

All models equipped with automatic cycle controls and breathing and ejection features. Heating and cooling equipment attachments and features as required.

COMPRESSION MOLDING MACHINES

	AUTOMOLD CO., LOS ANGELES, CALIF.				BALDWIN-LIMA-HAMILTON CORP., HAMILTON, OHIO			FRED S. CARVER, INC., SUMMIT, N.J.	
Model No.	A50-B	A25-B	A10	A60-T	–	–	–	Laboratory press	
Pressing capacity, tons: Compression	60	30	12	Clamping min. 60	100	200	300	10	20
Transfer	–	–	–	12	28	50	78	–	–
Hydraulic line pressure, p.s.i.	Air toggle for platen clamp. 120 p.s.i. (pneumatic with toggle action)			1000 Max.	2000	2100	2000	Self-contained hand pump 7000	16,000
Max. mold dimensions, L x W, in.	14 x 6 x 16½	12¾ x 5 x 13¼	6 x 5 x 14¼	14 x 7½ x 16½	24 x 20	30 x 20	36 x 30	6 x 6 x 3	8 x 8 x 4
Max. stroke, in.	7-5/8 (Platen comp.)	6-5/8	6	12 (Transfer plunger)	12	15	18	5½[1]	6½
Drive, hp.	–	–	–	7½[1]	10	20	25	–	–
No. of platens	1	1	1	1	2	2	2	2	2
Daylight opening, in.	15-19	13-15	14¼	15-19	18	24	30	0-17 (Adjustable)	0-16
Max. demand of electric power, kw.	Heater cartridges generally require about 4800 watts, except Model A 10				–	–	–	Heating only -up to 2000 watts	
Air pressure required, p.s.i.	100-120		80-100	100-120	–	–	–	–	–
Volume of air required, cu. ft./min.	10.8	5.8	2.5	10.8	–	–	–	–	–
Max. closing speed, in./sec.	2	2	3	2	5.3	5.0	4.3	Varies; hand pump control	
Pressing speed, Max., in./sec.	–	–	–	–	.27	.27	.22	Hand pump	
Min., in./sec.	–	–	–	–	.27	.27	.22	control	
Max. opening speed, in./sec.	2	2	3	2	2.67	3.09	2.67	Gravity return; hand valve	
Cycle controls:	Automatic				Semi-automatic			Manual	
Breathing?	Yes	Yes	Yes	None	Yes	Yes	Yes	–	–
Ejection?	Top	Top	Top	Top	Mechanical			–	–
Type of heater	Cartridge (electric) or steam				–	–	–	Elec./steam/water	
Method of control	Fenwal 5411 controllers				–	–	–	Thermostat	
Type of cooling	–	–	–	–	–	–	–	Water	
Method of control	–	–	–	–	–	–	–	Hand valve	
Floor space, L x W, in.	30 x 36	36 x 30	(Bench model) 33 x 30	30 x 36 (+24 x 36 for hyd.)	66 x 30	90 x 36	96 x 36	Bench model 18 x 16 x 36	19 x 19 x 42
Approx. price range, $	Available on request				Available on request			Available on request	

Ft. Notes: AUTOMOLD: Attachment for molding threaded parts available on Model A50-B; side coring, if desired, available on Models A50-B and A25-B. [1]Motor for transfer pump when transfer is in use.

FRED S. CARVER: Various types of standardized laboratory accessories, molds, etc. available. [1]Adjustable screw extension prov

WATSON-STILLMAN PRESS DIV., FARREL-BIRMINGHAM CO., INC., ROCHESTER, N.Y.

Model No.	9382-C 9382-T	9379-C 9379-T	9330-C 9330-T	9383-C 9383-T	9384-C 9384-T	9322-C 9322-T	9386-C 9386-T	9565-C 9565-T	9792-C 9792-B
Pressing capacity, tons: Compression	50	100	150	200	300	500	850	1200	30
Transfer	C – T-12½	C – T-25	C – T-38	C – T-50	C – T-75	C – T-125	C – T-200	C – T-200	C – B-10
Hydraulic line pressure, p.s.i.	2300	2200	2300	2300	2350	2400	2400	2500	1200
Max. mold dimensions, L x W, in.	16 x 16	20 x 21	22 x 24	30 x 24	33½ x 27	40 x 32	46 x 44	54 x 44	12 x 12
Max. stroke, in. Compression/clamp	12	12	15	15	18	24	24	24	6
Transfer	C – T-9	C – T-9	C – T-12	C – T-12	C – T-14	C – T-18	C – T-22	C – T-22	C – T-6
Drive, hp.	3	5	5	10	10	15	25	25	5
No. of platens	2	2	2	2	2	2	2	2	2
Daylight opening, in.	25	28	30	32	38	54	54	60	18
Max. closing speed, in./min.	220	260	215	220	230	210	142	100	62
Pressing speed, Max., in./min.:	14	13.5	10	12.5	8.6	25	19	14	–
Min., in./min.:	3.5	3.4	2.5	3.1	2.1	2.1	2	1.4	–
Max. opening speed, in./min.	220	220	215	220	230	210	142	100	50
Floor space, L x W, in.	48 x 52	52 x 55	54 x 57	61 x 64	73 x 68	75 x 70	92 x 90	108 x 96	19 x 33

Manual and automatic single cycle controls and degassing features included on all models execpt 30 ton. Ejection on all models except 30 ton press is by stripper bars, hydraulically operated. Heating and cooling features optional.

BAKER BROS., INC., TOLEDO, OHIO

Pressing capacity, tons: Compression	60 or 75	100, 150, 175	200	300	450
Transfer	15	30	50	75	125
Hydraulic line pressure, p.s.i.	2700	3300	1750	2650	2000
Max. mold dimensions, L x W, in.	16 x 20	20 x 24	28 x 34	28 x 34	36 x 42
Max. stroke, in.	13	15	18	18	24
Drive, hp.	7.5	10	2 x 20	2 x 20	2 x 30
No. of platens	2	2	2	2	2
Daylight opening, in.	29	33	38	38	42
Max. demand of electric power, kw.	14	24	65	65	96
Air pressure required	80	80	80	80	80
Max. closing, pressing, and opening speed	6.7 in./sec.				
Min. pressing speed	Down to 0				
Floor space, L x W, in.	93 x 89.5	123 x 98.5	–	–	–

On all models: Electric heating; on-off controller with thermocouple; hydraulic side cores; adjustable feeder measuring loaderboard – all available. Control instruments furnished to customer's specs. as extras; additional floating platens available as extras. Other special features available to customer's specs.

DAVIDSON-KENNEDY CO., ATLANTA, GA.

Model No.	101	102	103	104	105	106	107	108
Pressing capacity, tons: Compression	50	50	100	100	100	200	200, 400	200
Hydraulic line pressure, p.s.i., max.	6000	6000	6000	6000	6000		6000	6000
Platen size, F to B, L to R, in.	19 x 26	28 x 36	28 x 36	32 x 46	38 x 53		48 x 48	50 x 100
Max. stroke, in. (Standard)	36	36	50	50	50		58	58
No. of platens (Stand.)	2	2	2	2	2		2	2
Daylight opening, in.	0-36	0-36	0-50	0-50	0-50		0-58	0-58
Max. demand of electric power, kw. (on 2 platens)	9	18	18	25	54		80	108
Air pressure required, p.s.i.	100	100	100	100	100		100	100
Vol. of air required, cu. ft./min. (based on 2 strokes/min.)	10	10	18	25	40		50	80
Max. closing speed, in./min.	0-700	0-700	0-600	0-600	0-500		0-400	0-350
Max. pressing speed, in./min.	0-15	0-15	0-15	0-15	0-15		0-15	0-15
Max. opening speed, in./sec.	300	300	300	300	300		300	300
Approx. floor space, L x W, in.	24 x 36	36 x 48	36 x 48	40 x 60	50 x 80		60 x 100	62 x 120

All models equipped with manual and automatic cycle controls with breathing and ejection features. Heating of platens is by electricity and steam with pyrometer controls. Cooling is by water and is automatically controlled. Attachments and auxiliaries available to suit customer specifications.

WABASH METAL PRODUCTS CO., INC., WABASH, IND.

Model No.	50-15	50-15	50-18	30-12	30-12	12-12	50-24	50-24
Pressing capacity, tons: Compression	50	50	50	30	30	12	50	50
Hydraulic line pressure, p.s.i.	9689	9689	9689	8486	8486	7643	9689	9689
Max. mold dimensions, L x W, in.	12 x 15	12 x 15	18 x 18	12 x 12	12 x 12	12 x 12	18 x 24	18 x 24
Max. stroke, in.	7	7	7	6	6	6	7	7
Drive, hp.	¾	Hand operated	¾	¾	Hand operated		¾	Hand operated
No. of platens	2	2	2	2	2	2	2	2
Daylight opening, in.	15	15	15	10	10	10	15	15
Max. demand of electric power, kw.	6000	6000	6000	4000	4000	4000	9000 watts	9000 watts
Floor space, L x W, in.	22 x 23½	22 x 23½	25½ x 27½	22½ x 23½	22½ x 23½		25½ x 27½	

Models No. 50-24 and 50-24 (hand-operated) equipped with gravity return; Models 50-15, 50-18, 30-12, and the electrically driven 50-24 equipped with automatic cycle controls. On all models, strip heaters thermostatically controlled are used; water is used as the cooling agent.

B.I.P. ENGINEERING LTD. SUTTON COLDFIELD, ENGLAND
(U.S. REP.: RALPH B. SYMONS ASSOC., INC., TIVERTON, R.I.)

Model No.	60	80	150	300	400	150 (S. Die Ram)
Pressing capacity, tons: Compression	67	90	168	336	448	168
Transfer	14	14	30	62	62	30
Hydraulic line pressure, p.s.i.	1000	1000	1000	1000	1000	1000
Max. mold dimensions, L x W, in.	12 x 12	18 x 18	20 x 20	30 x 30	36 x 36	18 x 18
Max. stroke, in.	14	14	18	24	24	18
Drive, hp.	5	5	7½	15	15	10
No. of platens	2	2	2	2	2	2/4
Daylight opening, in.	24	30	38½	47½	60	38½
Max. demand of electric power, kw.	8	12	14½	30	40	16
Air pressure required, p.s.i.	60-80	60-80	60-80	60-80	60-80	60-80
Max. closing speed, in./sec.	420	420	540	400	400	540
Pressing speed: Max., in./sec.	1	1	0.5	0.25	0.25	0.5
Min., in./sec.	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Max. opening speed, in./sec.	420	420	430	400	400	430
Floor space, L x W, in.	45 x 25¼	51¾ x 30⅛	72 x 39	75½ x 29½	81½ x 53⅜	89½ x 27⅜

On all models: Variable semi- and fully automatic cycle controls; automatic breathing features; ejection accomplished hydraulically or by hanging bar. Heating by low frequency induction, thermostatically controlled; cooling is by water, controlled by gate valve. Loading, stripping, and unscrewing attachments available; final slow closing and initial slow opening.

T.H. & J. DANIELS, LTD. GLOUCESTERSHIRE, ENGLAND

Model No.	75/19	100/28	150/28	150/50	250/28	250/50
Pressing capacity, tons: Compression	75	100	150	150	250	250
Transfer	19	28	28	50	28	50
Hydraulic line pressure, p.s.i.	3360	2240	2240	2240	2240	2240
Max. mold dimensions, L x W, in.	–	–	–	26 x 26	30 x 30	30 x 30
Max. stroke, in.	16	16	18	18	20	20
Drive, hp.	4	5	5	5	5	5
No. of platens	2	2	2	2	2	2
Daylight opening, in.	16	20	24	24	30	30
Air pressure required, p.s.i.	40-100	40-100	40-100	40-100	40-100	40-100
Max. closing speed, in./sec.	4-5	4-5	4-5	4-5	4-5	4-5
Max. pressing speed, in./sec.	0.14	0.13	0.10	0.10	0.06	0.06
Max. opening speed, in./sec.	4	3	3	3	2¾	2¾
Floor space, L x W, in.	31 x 40	30 x 50	32½ x 41½	32¼ x 41½	34 x 56	34 x 56

On all models, semi-automatic cycle controls and breathing features are available; hydraulic ejection bottom, mechanical ejection top or bottom. Heating is by electric or steam with Cambridge thermostat controls; cooling is by water.

Also available: interlocked safety guards; speed control valves; multi-press units operating from single pump; column type construction facilitating addition of core pulling cylinders.

A. TRIULZI s.a.s., MILAN, ITALY

Model No.	Moldmatic 200T.	Moldmatic 300T.	Moldmatic (oil) 400T.	Moldmatic 500T.	Moldmatic 800T.	Moldmatic 1000 T.
Pressing capacity, tons: Compression	220	350	450	550	880	1100
Transfer	55	60	70	97	135	180
Hydraulic line pressure, p.s.i.	2130	2130	2130	2130	2130	2130
Max. mold dimensions, L x W, in.	27½ x 25½	31½ x 29½	31½ x 31½	37½ x 34	46½ x 38½	51 x 60
Max. stroke, in.	27½	27½	33½	33½	44	60
Drive, hp.	13	20	20	26	40	50
No. of platens	1	1	1	1	1	1
Daylight opening, in.	42	42	51½	51½	67	86
Max. demand of electric power, kw.	11	20	20	22	25	48
Air pressure required, p.s.i.	70	70	70	70	70	70
Max. closing speed, in./sec.	4	4	3½	3½	3	3
Pressing speed: Max., in./sec.	½	½	⅖	⅖	¼	¼
Min., in./sec.	ADJUSTABLE UP TO O					
Max. opening speed, in./sec.	4¼	4¼	3¾	3½	3½	3¼
Floor space, in.	95 x 90 x 240	100 x 90 x 250	105 x 90 x 260	105 x 93 x 305	125 x 97 x 340	140 x 110 x 380

All models equipped with automatic cycle controls and breathing and ejection features. Heating is by electricity and it is controlled by thermostatic feelers; cooling is accomplished by air and is similarly controlled. All models are equipped with a cushioning device to retard clamping. Other automation features to customer's specifications.

Automatic record molding press, multiple platen press for laminates, and special presses for molding reinforced plastics also available.

Production range covers water-hydraulic machines or oil-hydraulic machines with a clamping force from 45 to 1500 tons for direct compression or transfer molding. These units can be delivered hand-operated or equipped for automatic cycle control. The direct compression molding presses, if equipped with automatic devices, can be supplied with extra equipment for the automatic filling of the mold.

COVEMA, S.R., L., MILAN, ITALY
(U.S. REP. – RAINVILLE CO., INC., GARDEN CITY, L.I.)

Model No.	Potvel 35	Potvel 60 and 60TR	Potvel 100 and 100TR	Potvel 175 and 175TR	Potvel 250 and 250TR	Potvel 500 and 500TR
Pressing capacity, kg.: Compression	5000 + 35,000	10,000 + 62,000	20,000 + 100,000	35,000 + 195,000	55,000 + 270,000	100,000 + 500,000
Transfer	–	TR-17,600	TR-17,600	TR-21,000	TR-28,000	TR-35,000
Hydraulic line pressure, p.s.i.	3000	3000	3000	3000	3000	3000
Max. mold dimensions, L x W x H, in.	12⅝ x 11	16 9/16 x 15	20 7/16 x 19	23 x 24 7/16	26⅜ x 25	30⅜ x 29
Max. stroke, in.	12	16	20	22	24	29 9/16
Drive, hp., if electric	2.5	2.6	5	8	10	15
No. of platens	2	2	2	2	2	2
Daylight opening, in.	14	18	22	24	27⅝	33 7/16
Max. demand of electric power a. Elec. power pump, w.	1900	1900	3700	5900	7350	11,000
b. Heating platens, w.	2800	5000	8000	11,400	13,400	22,800
c. Maintaining temp., w.	1000	1600	1600	3800	4400	7600
Max. closing speed, m./min.	3.6	4.8	6	6	4	3
Max. pressing speed, m./min.	0.34	0.2	0.2	0.2	0.16	0.12

EMHART MFG. CO., PORTLAND, CONN.

Model No.	IPM 32	IPM 34	IPM 50-1	IPM 50-2	IPM 50-3	IPM 49		IPM 48	IPM 50-4
						1	2		
Forming area, L x W, in.: Max.	6" dia.	11 x 9	24 x 36	28 x 50	40 x 17	16x16	16x22	22 x 22	50 x 74
Min.	1½" dia.	1 x 1	1 x 1	1 x 1	1 x 1	1 x 1		1 x 1	1 x 1
HEATING: Heater area, L x W, in.	6" dia.	11 x 9	27 x 38	33 x 55	47 x 76	20½ x21⅜	20½ x27⅞	28 x 28½	56 x 80
Max. output, kw.	–	30 w/in.^{2}	21,000	42,000	67,500	8400	10,200	36,000	84,000
Operating temp., F: Max.:	–	–	1150	1150	1150	900	900	1100	1150
No. of independentally controlled zones	1	1	1	3	3	1		2	3
One- or two-side heating?	1	1	1	1	1	Either		2	1
Distance between bottom of heater element to top of sheet: Max., in.:	CONTACT		ADJUSTABLE to 21"	to 21"	to 21"	3		7	to 21"
Min., in.:	–	–	5	5	5½	3		3	5½
COOLING: No. of fans/blowers:	None	None	1 (optional)	2 (optional)	2 (optional)	None		None	2 (optional)
Can water lines be brought into mold?	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes
Can water mist be used safely?	No	No	No	No	No	No		No	No
FORMING FEATURES: Techniques available	Air Pressure		Vacuum and Drape			Vacuum and Plug-Assist			Drape
Max. depth of draw, in.	½	3	14	14	14	9		9	14
Rate of advance of plug, in./sec.: Max.:	ADJUSTABLE								
VACUUM SYSTEM: Pump motor output, hp.	–	–	2	3	7½	¼		2	2½
Pumping capacity at 1 atm., cu. ft./min.	12	–	22	38	80	3		28	80
Surge tank volume, cu. ft.	None	–	5.9	10.8	43	2.8		5.9	43
Is working pressure continuously variable over range?	Yes	Yes	–	–	–	No		–	–
INSTRUMENTATION FURNISHED: Timers available:	For forming, heating, and cooling cycles								
Type of vacuum control	–	–	Timer	Timer	Timer	Timer		Timer	Timer
Type of heater control	THERMOSTAT								None
Is sheet temp. indicated?	No	No	No	No	No	No		No	No
PRODUCTION FEATURES: No. of work stations	6	1	1	1	1	1		1	1
Auto. clamp release?	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes
Built-in trimming?	Pre-trimmed blanks used	Yes	No	No	No	Yes		Yes	No
Sheet or roll feeding?	Sheet	Both	No	No	No	Manual roll		Sheet	Sheet
Ejection aids?	Air & Mech.		–	–	–	Yes		–	Yes
Price of standard unit, FOB your plant	39,500	11,722	6250	9575	13,750	1400-3200		13,000	14,750

Model IPM 32 is a fully automatic unit for pre-blanked discs and operates up to 6000 pieces per hour. Model IPM 34 is a fully automatic unit for roll feed operation and can obtain speeds up to 20 per min. using sheet up to 10 mil thick. On Models IPM 50-1, IPM 50-2, IPM 50-3, and IPM 50-4, the heater can be tilted. Model IPM 48 is equipped with a sandwich heater.

SHEET FORMING MACHINES	ABBOTT PLASTIC MACHINE CORP., CHICAGO, ILL.					BORKLAND MFG. CO., MARION, IND.	
Model No.	SP-500	APM 30	APM 40	APM 60	APM 90	100	600
Forming area, Maximum L x W, in.	20 x 26	30 x 30	40 x 40	60 x 60	60 x 90	24 x 24	80 x 36
HEATING: Heater area, L x W, in.	30 x 36	36 x 36	48 x 48	72 x 72	72 x 96	24 x 24	86 x 36
Max. output	7.5 Kw.	10 kw.	16 kw.	32.4 kw.	46.8 kw.	8800 watts	53,000 watts
Operating temp., F.: Max.:	–	–	–	–	–	1500	1500
Min.:	–	–	–	–	–	700	700
No. of independentally controlled zones	1	1	1	3	3	2	6
One- or two-side heating?	One (two sides extra)					1	2
Distance between bottom of heater element to top of sheet: Max., in.:	6	8	10	14	14	Variable 6	12
Min., in.:	2	2	2	2	2	4	6
COOLING: No. of blowers/fans	1 (Extra)	2 (Extra)	2 (Extra)	2 (Extra)	2 (Extra)	1	2
Can water lines be brought into molds?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Can water mist be used safely?	Yes	Yes	Yes	Yes	Yes	No	No
FORMING FEATURES: Techniques available:	Vacuum; drape; free; air pressure (plug and ring, snap-back, plug assist, and air-bubble assist are extra optional)					Vacuum; drape; plug and ring; free; snap-back; plug-assist air-bubble-assist; air pressure	
Max. depth of draw, in.	6	8	10	14	14	6	12
Rate of advance of plug, in./sec.: Max.:	–	Extra – to specifications –	–	–	–	6	12
Min.:	–	–	–	–	–	1	1
VACUUM SYSTEM: Pump motor output, hp.	1/3	½	1	3	5	¾	1½
Pumping capacity at 1 atm., cu. ft./min.	5.6	9	18	52	72	15	25
Surge tank volume, cu. ft.	4	4	9	16	25	20	40
Time needed to pump down to 3 p.s.i.a., sec.	60	60	60	60	60	–	–
Working pressure, p.s.i.a., lowest	1 in.	1 in.	1 in.	5 in.	5 in.	7	5
highest	27	27	27	27	27	23	26
Is working pressure continuously variable over range?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
INSTRUMENTATION FURNISHED: Timers available:	For heating, forming, and cooling cycles					For heating, forming, cooling cycles	
Type of vacuum control	Ball valve (string release) ball release					Electrical	
Type of heater control	None	None	None	West Inst.		Rheostat	Unit and time cycle
Is sheet temp. indicated?	No	No	No	Yes	Yes	No	No
PRODUCTION FEATURES: No. of work stations	1	2	2	2	2	1	2
Auto. clamp release?	No	No	No	Extra		No	No
Built-in trimming?	Yes	No	No	No	No	No	Optional
Sheet or roll feeding?	Roll	Roll	Roll	–	–	Sheet	Both
Ejection aids?	No	Yes	Yes	Air	Air	Yes	Yes
Price of standard unit, FOB plant	2650[1]	4939	5889	8700	11,400	–	–

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[1] Will lease 36 mos. at $65/month.

CONAPAC CORP., NEW YORK, N.Y.

Model No.	Formvac U-5	Formvac U-7	Formvac junior	Formpack R-4	Formseal	Formvac G-1
Forming area, L x W, in. Maximum	60 x 40	80 x 60	12 x 10	12 x 10	10 x 10	36 x 24
Minimum	14½ x 14½	14½ x 14½	3 x 3	5⅝ x 3⅛	0	–
HEATING: Heater area, L x W, in.	62 x 42	82 x 62	12½ x 10	13 x 10	4 x 11	38 x 26
Max. output	42 kw.	75 kw.	3 kw.	24 kw.	–	15,000 w.
Operating temp., F.: Max.:	930	930	930	930	–	1800
Min.:	235	235	235	–	–	1800
No. of independentally controlled zones	12	24	1	4	Variable	2
One- or two-side heating?	2	2	1 (with reflect.)	2	2	1
Distance between bottom of heater element to top of sheet: Max., in.:	6	6	2	4	2	Variable
Min., in.:	6	6	2	4	2	–
COOLING: No. of fans/blowers:	–	–	–	–	–	–
Can water lines be brought into molds?	Yes	Yes	Yes	Yes	Yes	Yes
Can water mist be used safely?	Yes	Yes	Yes	Yes	No	Yes
FORMING FEATURES: Techniques available	Vacuum, drape, plug and ring, plug assist, air slip, air pressure				Vacuum, plug-assist, air-bubble assist, air press.	Vacuum, drape, plug & ring, air slip
Max. depth of draw, in.	24	32	8	6	3¼	14
Rate of advance of plug, in./sec.: Max.:	33	33	33	160	0.5	–
in./sec.: Min.:	18	18	15	160		–
VACUUM SYSTEM: Pump motor output, hp.	3 systems 2.5 / 7 / 7	7	¾	2.5	–	–
Pumping capacity at 1 atm., cu. ft./min.	30 / 90 / 144	144	4.5	30	–	–
Surge tank volume, gal.	85 / 170 / 255	255	29	–	–	–
Is working pressure continuously variable over range?	No	No	No	–	–	–
INSTRUMENTATION FURNISHED: Timers available:	For heating, forming, and cooling cycles		For heating cycle	–	For heating, forming, and cooling cycle	For heating & cooling cycles
Type of vacuum control	Vacumeter		Vacumeter		–	Electro-magnetic valves
Type of heater control	Switch	Switch	None	Rheostat switch		Relay timer
Is sheet temp. indicated?	No	No	No	No	No	No
PRODUCTION FEATURES: No. of work stations	1	1	1	1-4 (rotary)	1	1
Auto. clamp release?	Yes	Yes	No	Yes	Yes	Yes
Built-in trimming?	No	No	No	Yes	Yes	No
Sheet or roll feeding?	Sheet	Sheet	Sheet	Both	Roll	Both
Ejection aids?	Air	Air	Air	Air	Air	Air

ADDITIONAL INFORMATION: Note that in G series, Models G-5 and 2G5 (with 60 by 40 in. maximum forming area) and Models G-6 and 2G6 (with 72 by 48 in. maximum forming area) are also available; both have maximum depth of draw of 22 in. and are equipped with 1 or 2 work stations.

The Formseal model is a new machine designed to form, fill, seal, and trim in one completely automatic unit. The Formpack R-4 is a new high-speed rotary unit that operates completely automatically. The Formvac junior is a laboratory model designed to offer a wide range of forming techniques. The U-5 model offers airslip forming, cellular heaters, clamp, table, and plug forces, and a patented vacuum system.

SHEET FORMING MACHINES	THERMOMAT CO., INC., TRENTON, N. J.			ZACK RADIANT HEAT CO., LODI, N.J.	
Model No.	H1818	SP2234	PP3648	24 x 36	19 x 24
Forming area, Maximum L x W, in.	18 x 18	34 x 22	48 x 36	34 x 22	22 x 17
HEATING: Heater area, L x W, in.	(Rod) 22 x 22	(Rod or Mat) 36 x 24	50 x 38	39 x 27	26 x 21
Max. output	5500	9500-6048	19,900-13,600	10,000	6000
Operating temp., F.: Max.:	1200	1200-700	1200-700	—	—
Min.:	400	400	400	—	—
No. of independentally controlled zones	1	1	1	1	1
One or two-side heating?	1	1	1	1	1
Distance between bottom of heater element to top of sheet: Max., in.:	9	4	6	3	3
Min., in.:	3	3	3	2	2
COOLING: No. of fans/blowers:	1 (extra)	1	2	–	–
Can water lines be brought into molds?	Yes	Yes	Yes	Yes	Yes
Can water mist be used safely?	Yes	Yes	Yes	–	–
FORMING FEATURES:	Vacuum, drape (plug & ring and plug-assist extra)	Vacuum, drape	Vacuum, drape plug & ring, snap-back air-bubble assist	Vacuum, drape, skin packaging	Vacuum, drape, skin packaging
Max. depth of draw, in.	7	4	20	8	8
Rate of advance of plug, in./sec.: Max.:	–	–	24	–	–
VACUUM SYSTEM: Pump motor output, hp.	⅓	1	2	¾	¾
Pumping capacity at 1 atm. cu. ft./min.	3.8	17.0	21.0	9	9
Surge tank volume, cu. ft.	12	20	60	40	40
Time needed to pump down to 3 p.s.i.a., sec.	–	–	–	–	–
Working pressure, p.s.i.a., lowest	26	10	10	–	–
highest	26	26	26	–	–
Is working pressure continuously variable over range?	Manual	No	No	–	–
INSTRUMENTATION FURNISHED: Timers available:	For heating cycle	For heating, forming, and cooling cycles		For heating and forming cycles	
Type of vacuum control	None	Adj. relief		Relief valve	
Type of heater control	Percent timer	Ind. Pyrometer		Wheelco	
Is sheet temp. indicated?	No	No	No	No	No
PRODUCTION FEATURES: No. of work stations	1	1	1	1	1
Auto. clamp release?	No	Yes	Yes	Yes	Yes (semi)
Built-in trimming?	No	No	No	No	No
Sheet or roll feeding?	(Extra)	Both	No	Mill roll stand	
Ejection aids?	No	Under air		Air	Air
Price of standard unit, FOB plant	695	3950	7950	4100	2300

ADDITIONAL INFORMATION: THERMOMAT: Model SP2234 equipped with sliding platen for loading skin-pack items; also supplied with equipment for automatic cutting of formed sheet. Model PP3648 equipped with partial vacuum, flower-petal type clamp.

ZACK RADIANT HEAT: Custom build any size machine (manual, semi-automatic, or automatic). Equipped with fibrous glass radiant heater for heating film for skin-packaging.

	BROWN MACHINE CO., BEAVERTON, MICH.			COMET INDUSTRIES, FRANKLIN PARK, ILL.		
Model No.	222 (Standard)	223 – Rotary (Standard)	22C (Standard)	Meteor 3036	Star press 3036	Rotary-vac Obl.Pl. 3036
Forming area, L x W, in.,	(See Ft. Note 1, below)					
Maximum	36 x 30	72 x 42	36 x 30	36 x 30	36 x 30	36 x 30
Minimum	6 x 6	12 x 12	12 x 12	1 x 1	1 x 1	1 x 1
HEATING: Heater output, L x W, in.	Suff. overlap for max. areas			40 x 35	38 x 39	40 x 39
Max. output, watts	28,800	86,400	40,600	16.5 Kw.	44 Kw.	44 Kw.
Operating temp., F.: Max.:	–	–	–	1100	1100	1100
Min.:	–	–	–	100	200	200
No. of independently controlled zones	–	Optional		1	2	2
One or two-side heating?	2	2	2	1	2	2
Distance between bottom of heater element to top of sheet:	Adjustable			Adjustable		
Max., in.:	12 Top 16 Bot.	12 Top 14 Bot.	–	2-22	10 Top 20 Bot.	10 Top 20 Bot.
Min., in.:	8 Top 8 Bot.	8 Top 8 Bot.	–	2	10 Top	10 Top
COOLING: No. of fans and blowers:	1	2	–	1	2	2
Can water lines be brought into molds?	Yes	Yes	Yes	Yes	Yes	Yes
Can water mist be used?	Yes	Yes	Yes	Yes	Yes	Yes
FORMING FEATURES: Techniques available	Vacuum, drape, plug & ring, free, snap-back, plug assist, air-bubble assist (See Ft. Note 2 below)			Vacuum drape free	Vacuum, drape, plug and ring, free, snap-back, plug-assist, air-bubble-assist, air pressure	
Max. depth of draw, in.	15[3]	15[3]	6[3]	15	28	14
Rate of advance of plug, in./sec.: Max.:	Adjustable			Adj. (with plug-assist attach.)	Adj.: 15-9.6-5	
in./sec.: Min.:	–	–	–	5 (Range variable)		
VACUUM SYSTEM: Pump motor output, hp.	1.5[4]	3.0[4]	1.5[4]	½	2	2
Pumping capacity at 1 atm., cu. ft./min.	21.6	43.2	21.6	9	20	40
Surge tank volume	65 gal.	65 gal.	65 gal.	39.2 gal.	112 gal.	112 gal.
Time needed to pump down to 3 p.s.i.a., sec.	–	–	–	30	25	25
Working pressure, p.s.i.a., lowest	–	–	–	5	5	5
highest	–	–	–	25 Hg.	27 Hg.	27 Hg.
Is working pressure continuously variable over range?	–	–	–	Yes	Yes	Yes
INSTRUMENTATION FURNISHED: Timers available	For heating, forming, and cooling cycles			For heating, forming, and cooling cycles		
Type of vacuum control	Manual, Auto.	Automatic		Manual, Auto.	Automatic	
Type of heater control	Time; distance	Time;dist.;percentage timer	Distance; Mach. speed	Input Percentage		
Is sheet temp. indicated?	No	No	No	No	No	No
PRODUCTION FEATURES: No. of work stations	–	–	–	Automatic Feed 1	1	3
Auto. clamp release?	No	Yes	See below	Yes	Yes	Yes
Built-in trimming?	No	No	No	No	Yes (light gage)	No
Sheet or roll feeding?	Sheet	Sheet	Roll, extruder	Both	Both	Sheet
Ejection aids?	Air	Air	Air	Yes	Yes	Yes
Price of standard unit, FOB plant	8500	16,500	15,500	4000	10,400	14,000

BROWN MACHINE: [1] Forming areas to 42 by 72 in. available in 222 series, to 44 by 84 in. available in 223 series, and to 36 by 30 in. available in 22C series. [2] Unit variations have been built for pressure. [3] Draw depths of 18 and 24 in. are available in both the 222 and 223 series. [4] For machines with greater depth of draw, additional pump and surge tank capacity are supplied.

ADDITIONAL INFORMATION: BROWN MACHINES: The 22C model is a continuous forming unit that operates directly from the extruder or from roll stock, either way, the sheet is moving at all times. After forming components act upon the sheet, they travel with it during the cooling cycle.

COMET INDUSTRIES: Star Press 3036: available with automatic roll feed for high production; compound forming; electrically driven platens; available with stroke up to 50 inches. Rotary-Vac Dbl. Pl. 3036: electrically operated platens; available with 50 in. stroke; forming areas – 36 by 50, 48 by 72, and 48 by 84. Meteor is also available with 36 x 60 and 48 x 72 in. forming areas; Star Press is available with 36 x 50, 48 x 72, and 48 x 84 in. forming areas. The company also has a line of Packaging machines for blister and skin packs.

SHEET FORMING MACHINES

ATLAS VAC-MACHINE CORP., ROCHESTER, N.Y.

Model No.	A-14	Z-21	J-36	H-18 (Lab model)	PAC 20	Form-N-Seal	Press Form-
Forming area, L x W, in., Max.:	14 x 14	25 x 25	36 x 36	18 x 15	20 x 20	8½ x 10½	20 x 2
Min.:	14 x 14	6 x 6	6 x 6	5 x 5	15 x 15	Adjustable	
HEATING: Heater area, L x W, in.	17 x 17	30 x 30	40 x 40	21 x 18	26 x 26	Contact 8½ x 10½	Con 21 x 2
Max. output, kw.	5	11	19	5	12	3½	8
Operating temp., F: Max.	1200	1200	1200	1200	1200	900	900
Min.	300	300	300	–	–	150	150
No. of independently controlled zones	–	Optional					Non
One or 2-side heating?	1	Optional				Contact	Cont
Distance between bottom of heater element to top of sheet: Max., in.:	8½	12	12	14	12	Contact	Cont
Min., in.:	4½	6½	6½	3	8	Contact	Cont
COOLING: No. of blowers	1	2	4	None	2	None necessary	
Can water lines be brought into mold?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Can water mist be used safely?	Yes	Yes	Yes	Yes	Yes	Not nec.	Yes
FORMING FEATURES: Techniques available	Vacuum; drape; free; plug-assist	Vacuum; drape; plug and ring; free; snap-back; plug-assist; air-bubble assist; air pressure			Vacuum; drape	Pressure and vacuum forming	
Max. depth of draw, in.	Optional 6-8	Optional 8-12	Optional 8-15	8	5½	–	3½
Rate of advance of plug	Adjustable					–	Set
VACUUM SYSTEM: Pump motor output, hp.	⅓	½	1	⅓	1	½	½
Pumping capacity at 1 atm., cu ft./min.	4½	9	18	4½	18	4½	9
Surge tank volume	7 ft.^{3}	15 ft.^{3}	30 ft.^{3}	7 gal.	30 gal.	3 gal.	5
Working pressure, p.s.i.a., lowest	5 in.	5 in.	5 in.	5 in.	5 in.	150 max.	150 m
highest	29 in.	27 in.	27 in.	29 in.	27 in.		
Is working pressure continuously variable over range?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
INSTRUMENTATION FURNISHED: Timers available:	For air blow-off and heating, forming and cooling cycles						
Type of vacuum control	Solenoid			Electrical	Electrical	Electrical & manual	Electri
Type of heater control	Electrical						
Is sheet temp. indicated?	No	No	No	No	No	No	No
PRODUCTION FEATURES: No. of work stations	1	1	1	1	1	1	1
Auto. clamp release?	Yes	Yes	Yes	Manual	Yes	Yes	Ye
Built-in trimming?	No	No	No	No	Yes	Yes	Ye
Sheet or roll feeding?	Both	Both	Both	Both	Roll	Roll	Rol
Ejection aids?	Auto.-air	Auto.-air	Auto.-air	Mech. & air	Air blow	Auto.-air	Ai

In Models A-14, Z-21, and J-36, four styles of automation available: 1) manual pivot heater, air-operated drape frame, automatic heating, formin and cooling cycles, manual clamping and loading; 2) automatic heater, forming platens, cycles, manual clamping and unloading; 3) Same as 2 with automatic clamping and unclamping; 4) Completely automatic, forms, feeds, and ejects roll-fed materials.

The Pac 20 is an automatic in-line machine which trims to any shape and is capable of forming, blister work, and skin-packaging. The Pac 30 a larger version with a 30 by 30 in. maximum forming area.

The Form-N-Seal machine automatically forms a blister, trims it, and seals it to a pre-cut card. Automatic or manual filling of blister may be incorporated.

Similar to the forming part of the Form-N-Seal machine, another model called the Pressure Former is a fast production unit. It uses contact hea and pressure up to 20 cycles per minute.

Also available is Model REF-72 refrigerator door liner unit. This unit has a forming area 36 by 72 in. and incorporates the following forming techniques: vacuum, drape, plug and ring, snap-back, plug-assist, air-bubble-assist, and air-pressure. Max. depth of draw is 12 inches. It is equipp for automatic sheet loading and ejection.

COVEMA, s.r.l., MILAN, ITALY (U.S. Rep.: The Rainville Co., Inc., Garden City, N.Y.)

Model No.	605	1008	1510	Rotoform 203	Rotoform 608	Cutform 302
Forming area, Maximum L x W, in.	24 x 20	$39\frac{3}{8} \times 31\frac{17}{32}$	$59\frac{1}{16} \times 39\frac{3}{8}$	12 x 8	$31\frac{11}{32} \times 23\frac{21}{32}$	12 x 8
HEATING:						
Heater area, L x W, in.	$27\frac{5}{8} \times 24$	$43\frac{5}{16} \times 35\frac{7}{16}$	$63 \times 43\frac{5}{16}$	16 x 12	$35\frac{7}{16} \times 27\frac{5}{8}$	16 x 12
Max. output, kw	5	10	16	–	–	–
Operating temp., F.: Max.:	According to thickness			2192	2192	2192
Min.:				1832	1832	1832
No. of independentally controlled zones	According to infra-red elements; 1 zone for each element			One for resistance		
One or two-side heating?	1	1	1	2	2	2
Distance between bottom of heater element to top of sheet:	Can be registered					
Max., in.:	$98\frac{7}{16}$	$98\frac{7}{16}$	$98\frac{7}{16}$	$98\frac{7}{16}$	$98\frac{7}{16}$	$98\frac{7}{16}$
Min., in.:	$31\frac{17}{32}$	$31\frac{17}{32}$	$31\frac{17}{32}$	$31\frac{17}{32}$	$31\frac{17}{32}$	$31\frac{17}{32}$
COOLING:						
No. of fans-blowers	–	–	–	–	–	–
Can water lines be easily brought into molds?	Yes	Yes	Yes	Yes	Yes	Yes
FORMING FEATURES:						
Techniques available	Vacuum; drape; plug and ring; snap-back; plug-assist; air-bubble-assist; air pressure					
Max. depth of draw, in.	300	350	450	6	–	$5\frac{17}{32}$
Rate of advance of plug	Instantaneous			Instantaneous		
VACUUM SYSTEM:						
Pump motor output, hp.	1.2	1.2	2	–	–	1.2
Pumping capacity at 1 atm., Mc	25	40	60	–	–	–
Surge tank volume, liters	200	400	600	150	900	300
Time needed to pump down to 3 p.s.i.a., sec.	.5	.5	.5	.5	.5	.5
Lowest working pressure, atm.	4	4	4	4	4	4
Highest working pressure, atm.	8	8	8	8	8	8
Is working pressure continuously variable over range?	Constant			Constant		
INSTRUMENTATION FURNISHED:						
Timers available;	For heating cycle			For heating, forming, and cooling cycle		
Type of vacuum control:	Manometer vacuum gauge			Manometer vacuum gauge		
Type of heater control:	Infra-red rays			Infra-red rays		
Is sheet temp. indicated?	No	No	No	No	No	No
PRODUCTION FEATURES:						
No. of work stations	1-2 or more	1-2 or more	1-2 or more	1-2 or more	1-2 or more	1-2 or more
Auto. clamp release?	Yes	Yes	Yes	Yes	Yes	Yes
Built-in trimming?	Yes	Yes	Yes	Yes	Yes	Yes
Sheet or roll feeding?	Yes	Yes	Yes	Yes	Yes	Yes
Ejection aids?	Yes	Yes	Yes	Yes	Yes	Yes
Price of standard unit, FOB plant	2541	4446	6987	9315	12,702	10,575

SHEET FORMING MACHINES	ERDCO ENG. CORP., ADDISON, ILL.		PRECISION PRODUCTS CO., PATERSON, N. J.		
Model No.	OIA-BFS	OIA-BT	2; 2A	3; 3A	4; 4A; 4B
Forming area, L x W, in: Maximum:	11 x 10	26 x 21	8½ x 8½	10½ x 10½	20 x 10
Minimum:	½ x 6	½ x 6	–	–	–
HEATING: Heater area, L x W, in.	–	–	11 x 11	11 x 11	11 x 22
Max. output, w.	–	–	1100	1100	2200
Operating temp., F: Max.:	–	–	700	700	700
Min.	–	–	700	3-700 3A-700	700
No. of independently controlled zones	–	–	0	3-0 3A-0	2
One or two-side heating?	–	–	1	1	1
FORMING FEATURES: Techniques available	Vacuum; drape; plug-and-ring; plug-assist		Hand operated-vacuum		
Max. depth of draw, in.	3	3	2-2; 2A-3	3-2; 3A-3	4-1; 4A-2; 4B-3
INSTRUMENTATION FURNISHED:	–	–	NONE		
Timers:	For heating and forming		None	None	None
PRODUCTION FEATURES: No. of work stations:	1	1	1	1	1
Auto. clamp release?	Yes	Yes	No	No	No
Built-in-trimming?	Yes	Yes	No	No	No
Sheet or roll feeding?	Yes	Yes	–	–	–
Ejection aids?	Yes	Yes	–	–	–
Price of standard unit, FOB plant, $	–	–	2-89.50 2A-99.50	3-122 3A-132	4-175; 4A-190; 4B-220

PRECISION PRODUCTS CO.: All units can be equipped with motorized vacuum and blow-back ejection aids.

	AIR-O-FLOW INDUSTRIES, INC., NEW YORK, N. Y.								
Model No.	200-3036	200-3652	200-OH 3036	200-OH 3652	200-OH 3672	400-04 4872	400-3036	400-3652	400-OH 3652
Effective forming area, in.	30 x 36	36 x 52	30 x 36	36 x 52	36 x 72	48 x 72	30 x 36	36 x 52	36 x 52
Dia. of bottom ram cylinder, in.	8	12	8	12	12	14	8	12	12
Stroke of bottom ram cylinder, in.	18	18	18	18	24	24	18	18	18
Dia. of overhead ram cylinder, in.	None	None	6	8	10	12	None	None	8
Stroke of overhead ram cylinder, in.	None	None	24	30	30	36	None	None	30
Type of heater	Overhead single heater		Sandwich double-heater				Overhead single heater		Sandwich
Single or double stage operation?	Single	Single	Single	Single	Single	Single	Double	Double	Double
Nominal over-all dimensions, ft.	6 x 8	7 x 9	6 x 8	7 x 9	9 x 9	9 x 11	6 x 12	7 x 14	7 x 14

AIR-O-FLOW: Additional information: All machines can be adapted to practically every known method of thermoforming, including vacuum, pressure, plug-assist, ridge, air pressure, male and female, etc. Model 400-OH-5492 is a single-stage machine with sandwich table heater and can be had in a standard size of 54 by 92 inches.

	THE AUTO-VAC CO., BRIDGEPORT, CONN.			TABER INSTRUMENT CORP., N. TONAWANDA, N. Y.		T. H. & J. DANIELS, GLOUCESTSHIRE, ENGLAND		
Model No.	LAB-VAC	PRO-VAC	EQA	146	178	30/30	40/30	80/50
Forming area, L x W, in. Maximum:	15¾ x 15¾	30 x 24	(5 sizes) 72 x 48	(dia.or oval) 8½ x 8½	30 x 12	30 x 30	40 x 30	80 x 50
Minimum:	4 x 4	12 x 12	6 x 6	1½ x 1½	1/8 x 1/8	–	–	–
HEATING: Heater area, L x W, in.	21 x 18	34 x 27½	–	–	31 x ½	34 x 34	44 x 34	84 x 54
Max. output, watts	3200	11,220	44,378	2300	1500	9000	18,000	70,000
Operating temp., F.: Max.:	1200	1300	1300	500	500	–	–	–
Min.:	–	0	0	50	50	–	–	–
No. of independently controlled zones	0	0	–	1	1	To customer's spec.		
One- or two-side heating?	1	1	1	2	1	1	2	2
Distance between bottom of heater element to top of sheet: Max., in.:	Adjustable 4	Adjustable 6	12	2	6	Variable		
Min., in.:	2	2½	2½	2	6	–	–	–
COOLING: No. of fans supplied:	Optional	Optional	–	None	None	–	–	–
Can water lines be brought into mold?	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Can water mist be used safely?	Yes	Yes	Yes	No	No	Yes	Yes	Yes
FORMING FEATURES: Techniques available	Vacuum; drape; plug and ring; free; snap-back; plug-assist; air-bubble-assist (LAB-VAC uses 30 p.s.i. air press.)			Air pressure	Air press. (for folding only)	Vacuum; drape; plug and ring; free; snap-back; plug-assist; air-bubble assist		
Max. depth of draw, in.	8½	10	15	1	–	10	20	22
Rate of advance of plug, in./sec.: Max.:	36	36	36	–	–	–	–	–
Min.:	2	2	2	–	–	–	–	–
VACUUM SYSTEM: Pump motor output, hp.	–	¾	2-5	–	–	–	–	–
Pumping capacity at 1 atm., cu. ft./min.	–	–	–	–	–	–	–	–
Surge tank volume, cu. ft.	–	7	–	–	–	–	–	–
Time needed to pump down to 3 p.s.i.a., sec.	–	–	30	–	–	–	–	–
INSTRUMENTATION FURNISHED: Timers:	Optional for heating, forming, cooling	For heating, forming, cooling	For heating, forming, cooling	None (auto. controlled)	For cooling cycle (for folding only)	For heating, forming, and cooling cycles		
Type of vacuum control	–	Electrically operated	Automatically timed	–	–	–	–	–
Type of heater control	–	Wheelco	Wheelco	Pyrometer	Thermoswitch	–	–	–
Is sheet temp. indicated?	No	No	Optional	Yes	Yes	No	No	No
PRODUCTION FEATURES: No. of work stations	1	1	1	1	1	1	1	1
Auto. clamp release?	Optional	Yes	Yes	No	No	No	Yes	Yes
Built-in trimming?	Optional	Optional	Optional	Yes	No	No	No	No
Sheet or roll feeding?	Both	Optional	Both	Sheet	Sheet	Both	Both	Both
Ejection aids?	Yes	Blow-off	Yes	Blower operated by solenoid	No	Air	Air	Air
Price of standard unit, FOB plant	695 (plus accessories)	3500 (plus accessories)	5950 and up	4350	2295	6200	9500	21,000

AUTO-VAC: PRO-VAC is a semi-automatic combination drape and vacuum unit; LAB-VAC is designed to perform like the production model; EQA features automatic forming cycles.

TABER: No. 146 is designated Thermatic drawpress; No. 178 is designated Thermatic folder-creaser.

BLAW KNOX CO.—AETNA STANDARD DIV., PITTSBURGH, PA.
Sales and engrg. by HALE & KULLGREN, INC., AKRON, OHIO

1. Model No.	1H15	1H25	1H35	1H45	1H60	1H80
2. Nominal screw dia., in.	1½	2½	3½	4½	6	8
3. L/D ratios available	20:1	20:1 & 25:1	20:1 & 24:1	20:1 & 24:1	20:1 & 24:1	20:1 & 24:1
4. Type of transmission	Single reduction helical	Double reduction herringbone				
5. Eff. of transmission at full load, %	96	96	96	96	96	96
6. Type of thrust bearing	Tapered roller; radial thrust			Cylindrical roller; flat thrust		
7. Recommended drive, hp.	5.0-7.5	25-30	50-75	75-100	150-200	200-300
8. Screw speed range, r.p.m.	33-200	11-175[1]	10-150	9-140	8-120	6-100
9. Max. output of polyethylene (dens.-0.92; MI-2) at 400° F. and 2000 p.s.i., lb./hr.	75	175	375	700	1200	2000
10. Type of cooling system (cylinder)	Water[2]					
11. Cooling system (hopper)	Water					
12. Safe operating head pressure[a], p.s.i.	10,000					
13. Materials of construction: a) for screw	.40/.50 c. alloy steel or stainless steel; screw flights hard surfaced					
b) for barrel	Alloy steel with Xaloy or Xaloy #306 lining					
14. Temperature controls, type	Three position, non-proportioning, with thermocouple break protection					
15. Type of heater	Induction coils					
16. No. of zones in barrel heater	3	4[3]	5[3]	5[3]	6[3]	6[3]
17. Approx. heat-up time to 350° F.	6 min.[4]	12 min.[4]	15 min.[4]	18 min.[4]	20 min.[4]	30 min.[4]
18. Max. total heater wattage, kw.	3.0 min.[5] 6.3 max.	7.5 min.[5] 13 max.	20 min.[5] 29.0 max.	65 min.[5] 71 max.	90.0 min.[5] 100 max.	200 min.[5]
19. Venting and devolatilizing features	Available					
20. Approx. delivery time, wks.	Varies from 8-20 weeks, depending upon backlog of work and special engineering required					

[a] Assuming safety factor of 4.

[1] Can be varied to suit customer's requirements. [2] A distilled water circulation system provided.

[3] Includes 1 zone induction heat on head. [4] Time required using minimum kw. from barrel heaters. [5] Induction coils are tapped to provide a range of input kw.

DAVIS-STANDARD, DIV. OF FRANKLIN RESEARCH CO., MYSTIC, CONN.

1.	15T	200T	25T	35T	45T	60T	80T
2.	1½	2	2½	3½	4½	6	8
3.	20:1[1] 25.8:1	16:1[1] 22:1	20.0:1[1] 24.6:1	20.0:1[1] 24.6:1	15.3:1; 20.0:1; 24.7:1[1]		15.3:1[1] 20.0:1
4.	Heavy timing belt drive from gear head motor	Worm and wheel	Helical gears				Herringbone gears
5.	99	92	98	98	98	98	98
6.	Rollway flat roller						
7.	–	15-25[2]	25-40[2]	50-60[2]	75-100[2]	125-200[2]	200-300[2]
8.	Max.: 50-200	Max.: 60-180	Max.: 50-200	Max.: 50-150	Max.: 50-135	Max.: 40-100	Max.: 40-60
9.	55 at 100 R.P.M.	100 at 150 R.P.M.	200 at 200 R.P.M.	400 at 150 R.P.M.	600 at 125 R.P.M.	1100 at 95 R.P.M.	1600 lb. at 70 R.P.M. with 20:1 ratio
10.	Aluminum finned heater with individual large capacity blower						
11.	Water[3]						
12.	10,000 p.s.i. and higher						
13. a)	4140 Alloy – Heat treated – Flame hardened flights						
b)	One-piece steel with cast-in Xaloy liner						
14.	Proportional control for each zone						
15.	Tubular heater cast into aluminum						
16.	2 for 14.2:1 3 for 20:1 4 for 25.8:1	2 for 16:1 3 for 22:1	3 for 15.4:1 4 for 20.0:1 5 for 24.6:1	3 for 15.4:1 4 for 20.0:1 5 for 24.6:1	3 for 15.3:1 4 for 20.0:1 5 for 24.7:1	3 for 15.3:1 4 for 20.0:1 5 for 24.7:1	3 for 15.3:1 4 for 20.0:1
17.	15	20	15	25	30	40	60
18.	6 for 14.2:1 9 for 20:1 12 for 25.8:1	7.2 for 16:1 10.8 for 22:1	15 for 15.4:1 20 for 20.0:1 25 for 24.6:1	21 for 15.4:1 20 for 20.0:1 25 for 24.6:1	30 for 15.3:1 40 for 20.0:1 50 for 24.7:1	42 for 15.3:1 56 for 20.0:1 70 for 24.7:1	60 for 15.3:1 80 for 20.0:1
19.	Available						
20.	2 to 16, depending on time and special design requirements						

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[1] Excluding feed opening. [2] Depending on speed [3] Cooling system (feed section)

ALSO NOTE: Screw speed ranges as noted give maximum screw speed plus other possible maximum range as certain installations may require; however, screw speed ranges for any given maximum is depended on drive.

ADDITIONAL INFORMATION: AGMA capacity of gearing with service factor 1.25: 15T - No gearing; 200T - 26 H.P. at 100 R.P.M., 30 H.P. at 150 R.P.M.; 25T - 36 H.P. at 100 R.P.M., 64 H.P. at 200 R.P.M.; 35T - 75 H.P. at 100 R.P.M., 107 H.P. at 150 R.P.M.; 45T - 131 H.P. at 100 R.P.M., 154 H.P. at 125 R.P.M.; 60T - 200 H.P. at 80 R.P.M., 225 H.P. at 100 R.P.M.; 80T - 200 H.P. at 60 R.P.M., 308 H.P. at 60 R.P.M.

ADDITIONAL FEATURES: Completely wired control panels. Electric stock screw tachometer. Separate thrust and radial bearings. Labyrinth oil seals. Water-cooled feed section. Oversized stainless steel hoppers with shut-off and level indicator. Screw flights extend beyond feed throats. One piece cylinder. Four-splined stock screw with tapered drive end. Therma-Fin Temperature control. Wide opening head clamp. Head support swings clear of machine. V-belt drive. Easily removed feed throat bushing. Visual oil gage. Water-cooled screw fittings.

EXTRUDING MACHINES	JMC CO., NEWARK, N. J.		KILLION TOOL & MFG. CO., VERONA, N. J.			PRODEX CO., FORDS, N. J.					
1. Model No.	150	250	–	–	–	175	250	350	450	600	800
2. Nominal Screw diameter, in.	1½	2½	¾	1	1½	1¾	2½	3½	4½	6	8
3. L/D ratios avail.	21:1		16:1 or 20:1	20:1	20:1	20:1 24:1 30:1	20:1 24:1 30:1	20:1 24:1 30:1	20:1 24:1 30:1	20:1 24:1 30:1	20:1 24:1 30:1
4. Type of transmission	Herringbone		Gear box	Vari Drive		Helical	Herringbone				
5. Efficiency of trans., at full load, %	Approx. 97		–	–	–	95	95	95	95-97	95-97	95-97
6. Type of thrust bearing	Spherical Roller		Ball	Ball	Spherical Roller	Spherical Roller					
7. Recommended drive, hp.	5-10	15-25	½ or ¾	¾	3-5	7½-10	20-30	40-50	60-75	125-150	200-250
8. Screw speed range, r.p.m.	12-200	9-150	25-50	15-125	18-100	40-225	20-200	20-110	10-88	5-78	5-68
9. Max. output of P E (Dens.-0.92; MI-2) at 400° F. and 2000 p.s.i., lb./hr.	55	220	7	14	30	100	200	400	600	1100	1900
10. Type of cooling system (cylinder)	Air	Air	–	–	Water	Air	Air	Air	–	–	–
11. Cooling system (hopper)	Water		Water			Water					
12. Safe operating head pressure, p.s.i.[1]	10,000		–	–	–	10,000					
13. Materials of construction: a) For screw	Alloy steel chrome-plated		Stainless or Alloy steel		Alloy	Stellite tipped SAE 4140					
b) For barrel	One-piece alloy steel with Xaloy or Xaloy 306 cast interior		Stainless or Xaloy		Xaloy	Xaloy					
14. Temperature controls, type	Proportioning		Robert Shaw		Wheelco or West	Proportioning					
15. Type of heater	Replaceable tubular heater in aluminum housing		Band	Band	Band	Calrod					
16. Number of zones in barrel heater	2	3	2	2 or 3	3	2-3	4	4	4	5	6
17. Approx. heat-up time to 350° F., min.	16	23	20		30	25					
18. Max. total heater wattage, kw.	6	18	500EA	700EA	1200	7	15	30	40	85	98
19. Venting & devolatilizing features available	No	No	–	–	–	Yes	Yes	Yes	Yes	Yes	Yes
20. Approx. delivery time, weeks	3	3	2	2	6	4	6	8	10	12	14

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[1] Assuming safety factor of 4.

FARREL-BIRMINGHAM CO.
ANSONIA, CONN.

1.	C-250	Inductomatic D-350	D-450	D-600	13 x 8½	8½	12	15 x 12	15	20
2.	2½	3½	4½	6	8½	8½	12	12	15	20
3.	16:1 & 20:1	16:1 and 20:1		To suit	5:1	To suit	To suit	5:1	To suit	To suit
4.	Helical	Herringbone		Double reduction herringbone						Single Red. Her.
5.	97½	97½	97½	97½	97½	97½	97½	97½	97½	97½
6.	Tapered or flat roller			Flat Roller			Flat Roller			Kingsbury
7.	15 20	30 40	50 60	75-150	60-125 (All figures with 1.5 service factor)	100-300	125-600	125-200	200-600	500-2000
8.	7-120	6-100	5-90	10-100	4-40	8-80	8-75	4-45	4-40	0-35
9.	100-150	200-300	300-450	1000	3000	1500	3000	5500	7000	10,000
10.	Forced Air			Jacketed construction for water or steam						
11.	Forced Air or Water			Forced air or water	Water		Water		Water	
12.	Norm. max. 5000; possible max. 10,000			5000 - 15,000 depending on specifications						
13. a)	Alloy steel			Alloy or Stainless Steel				Alloy or Stainless Steel		
b)	Xaloy or Xaloy 306			Meehanite, cast steel, or welded steel, depending on pressures specified Xaloy liners						
14.	Automatic on-off			Manual or automatic				Manual or automatic		
15.	Induction			Induction, steam, oil, Dowtherm	Steam, Oil, or Dowtherm					
16.	2 or 3	3 or 4	3 or 4	Depends on number of cylinder sections						
17.	20	30	45	–	–	–	–	–	–	–
18.	13.5	27	33.6	–	–	–	–	–	–	–
19.	To customer's specs.			Provided to customer's specs.						
20.	6	6	6	Since machines are to specs., delivery times are 20 weeks and up						

ADDITIONAL FEATURES:

L/D ratios other than those listed above available on request. Complete control panel for accurate control of heating and cooling zones including an added zone for die heat control. Models 13 x 8½ and 15 x 12 have screw and hopper design to take a complete batch from the Banbury mixer. Standard or vented cylinders can be furnished. Continuous mixing or forcing screws also available. Sheet, strand, or underwater pellet die types available. Hydraulic breechblock, hydraulic or manual "C" clamp or swing bolt head types available. All extruder models designed for D.C. variable voltage, Eddy current coupling, Oilgear or American Blower fluid coupling, and A.C. motor type drives as required by customer.

MODERN PLASTIC MACHINERY CORP.
LODI, N.J.

1. Model No.	ESF 100-12	EF 150-20	EF-200-20	EF-250-20	EF 350-20	EF 450-20	EF 600-20	EF 800-20
2. Nominal screw dia., in.	1	1½	2	2½	3½	4½	6	8
3. L/D ratios available	12 : 1 18 : 1 20 : 1	20 : 1 24 : 1 30 : 1	20 : 1 24 : 1 30 : 1	20 : 1 24 : 1 30 : 1	20 : 1 24 : 1 30 : 1	20 : 1 24 : 1 30 : 1	20 : 1 24 : 1 30 : 1	20 : 1 24 : 1 30 : 1
4. Type of transmission	Worm	Silent chain	Herringbone					
5. Efficiency of transmission at full load, %	85	95	95	95	95	95	95	95
6. Type of thrust bearing	Cylindrical roller							
7. Recommended drive, hp.	½-1	5	10-15	20	30	75	125	200
8. Screw speed range, r.p.m.	6-62 9-93	14-93	7-85	7-85	7-85	5-70	6-76	8-72
9. Max. output of PE (Dens. – 0.92, MI – 2) at 400° F. and 2000 p.s.i., lb./hr.	6-15	25-35	50-75	80-135	150-250	300-400	450-700	1000-1500
10. Type of cooling system (cylinder)	None	Air	Air	Air	Air	Air	Air	Air
11. Cooling system (hopper)	Water	Water	Water	Water	Water	Water	Water	Water
12. Safe operating head pressure, p.s.i.[1]	10000	10000	10000	10000	10000	10000	10000	10000
13. Materials of construction: a) For screw	Stainless steel bright hardened	Steel hardened lands chromed						
b) For barrel	Xaloy 306	Xaloy 306	Xaloy 306	Xaloy 306	Xaloy 306	Xaloy 306	Xaloy 306	Xaloy 306
14. Temperature controls, type	Proportioning			Proportioning			Proportioning	
15. Type of heater	Band	Band; cast-in aluminum or induction					Band cast-in aluminum	
16. Number of zones in barrel heater	2	2	3	4	4	5	5	6
17. Approx. heat-up time to 350° F., min.	15	20	20	30	30	30	40	40
18. Max. total heater wattage, kw.	1.8-3.2	6.2	10.2	13.2	26.4	42.5	62	125
19. Venting and devolatilizing features available	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
20. Approx. delivery time, wks.	6-10	6-10	6-10	10-12	10-12	10-12	16	20

[1] Assuming safety factor of 4.

ADDITIONAL INFORMATION:
1) High outputs available with high-speed extruders with higher HP drives; 2) Complete extrusion package setups available; 3) Floating screw available with 45 degree nose cone for valving and pressure control; 4) Extruders with valves, pressure gages, thermocouples, and other special items furnished on request.

FRANK W. EGAN & CO.
SOMERVILLE, N.J.

1.	–	–	–	–	–	–	–	–	–	–
2.	2	2½	2½	3½	3½	4½	4½	6	6	8
3.	20 : 1	24 : 1	32 : 1 (vented)	24 : 1	32 : 1 (vented)	24 : 1	32 : 1 (vented)	24 : 1	32 : 1 (vented)	24 : 1
4.	Herringbone									
5.	98	98	98	98	98	98	98	98	98	98
6.	Roller thrust									
7.	10-25	15-30	15-30	25-50	40-75	50-100	50-100	100-200	150-200	150-250
8.	Up to 250	Up to 200	Up to 150	150	125	125	96	96	84	72
9.	110	225	240	360	360	600	720	960	1200	1800
10.	Willert Temperature Control System (patented)									
11.	Direct water									
12.	As required									
13.	Heat treated alloy									
a)	Flame hardened flights-Chrome plate									
b)	One-piece heat treated alloy steel, Xaloy lined									
14.	3 position proportioning									
15.	Ceramic									
16.	3	4	4	4	5	4	–	–	–	5
17.	15	15	15	15	15	15	15	20	20	20
18.	16	28	28	42	42	72	72	160	160	192
19.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
20.	Stock to 2 wks.	Stock to 2 wks.	4-6	4	5	6	10	10	12	12

Standard equipment includes: a) Pre-wired temperature control panel with proportioning-type controller, three pole contactors, fused disconnect switch all mounted and pre-wired to JIC standards; b) Pre-wiring of heater bands and thermocouples to terminal strip; c) Hopper with cut-off slide, sight glass and emptying chute; d) Breaker plate; e) Head clamp; f) Guards.

Optional equipment available: a) Screw speed indicator; b) Screw extractors; c) Various detecting and controlling devices; d) Air-operated head clamps; e) Calrod heaters cast in aluminum or bronze, induction type, and thermostrip; f) Willert temperature control system; g) Special screw designs.

HARTIG EXTRUDERS, DIV. MIDLAND-ROSS CORP., MOUNTAINSIDE, N. J.

1. Model No.	–	–	–	–	–
2. Nominal screw dia., in.	1½	2½	3½	4½	6
3. L/D ratios available	20:1	20:1	20:1	20:1	20:1
4. Type of transmission	Torque-arm reducer	Herringbone Gear Type			
5. Efficiency of trans. at full load, %	Approximately 95				
6. Type of thrust bearing	–	–	–	–	–
7. Recommended drive, hp.	5-7½	15-25	25-40	50-75	100-150
8. Screw speed range, r.p.m.	25-125	10-125	10-100 (DC Drive)	10-85	10-85
9. Max. output of PE (Dens. -0.92; MI-2) at 400° F. and 2000 p.s.i., lb./hr.	30/45	90/120	180/240 Nominal capacity	300/400	500/700
10. Type of cooling system (cylinder)	Water and air				
11. Cooling system (hopper)	Water				
12. Safe operating head pressure, p.s.i.	5000 Normal (10,000 available) Based on safety factor of 2				
13. Materials of construction: a) For screw	Alloy steel				
b) For barrel	Steel with Xaloy or Xaloy 306 integral lining				
14. Temperature controls, type	Proportioning Pyrometer Type				
15. Type of heater	Extruded Aluminum				
16. No. of zones in barrel heater	2	3	3	4	4
17. Approx. heat-up time to 350° F., min.	25	25	25	25	25
18. Max. total heater wattage, kw.	9.2	14.3	26	44	68
19. Venting and devolatilizing features available	Yes	Yes	Yes	Yes	Yes
20. Approx. delivery time, wks.	–	–	–	–	–

NATIONAL RUBBER MACHINERY CO.
AKRON, OHIO

1.	50-12[1]	1½"- 55 EH	2½"EH or IH	3½"EH or IH	4½"EH or IH	6"EH	8" EH	10" EH	15"SH
2.	1	1-½	2-½	3½	4-½	6	8	10	15
3.	(See Footnote 2)		(See Footnote 3)						
	12 : 1, 17 : 1	16 : 1, 20 : 1, 24 : 1	16 : 1; 20 : 1, 24 : 1	16 : 1, 20 : 1, 24 : 1	16 : 1, 20 : 1, 24 : 1	16 : 1, 20 : 1, 24 : 1	16 : 1, 20 : 1, 24 : 1	16 : 1, 20 : 1, 24 : 1	16 : 1, 20 : 1 24 : 1
4.	Gear & belt	Chain type	Helical	Helical	Helical	Helical		Herringbone	
5.	85	95	85	97	97	97	95	95	95
6.	–	–	–	–	–	–	–	–	–
7.	¾	5	25	50	100	150	250	400	800
8.	21.3-58.7 48-132	125 top	120 top	100 top	90 top	80 top	70 top	60 top	60 top
9.	6-10 (nominal)	50	150	300	550	750	1500	3000	6000
10.	Ambient Atmosphere	Air or fluid							Fluid
11.	Water	Water	Water	Water	Water	Water	Water	Water	Water
12.	7500	7500	7500	10,000	10,000	10,000	10,000	10,000	10,000
13. a.	Alloy steel, chrome-plated, flame hardened			Alloy steel, chrome-plated, flame hardened			Alloy steel, chrome-plated, surface hardened		
b.	1-piece steel with integral Xaloy 306 lining								Alloy steel casting with Xaloy 306 lining
14.	Proportioning	Proportioning[4]		Proportioning	Proportioning[4]		Proportioning	Proportioning	Steam system
15.	Band	Cast-in	Cast-in or Induction[5]			Cast-in[5]	Cast-in		Steam
16.	2	2	4	4	5	5	6	7	8
17.	30	45	Resist. htr. - 60; Ind. htr. - 30		Resist. htr. - 60 Ind. htr. - 45	Resist. htr. - 960	90	90	240
18.	1.2	5.1	13.75	25.8	38.5	62	100	150	Steam
19.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
20.	4	4	5	6	4	6	12	16	20

[1] Table model; entire unit mounted on a solid base plate. [2] Available in vented type. [3] Available in vented type, 24: 1, L/D [4] Mounted in separate fabricated steel cabinet, prewired. [5] Oil and steam heated models (optional and available).

STERLING EXTRUDER CORP.
LINDEN, N.J.

1. Model No.	1½"	2"	2½"	3½"	4½"	6"
2. Nominal screw dia., in.	1½	2	2½	3½	4½	6
3. L/D ratios available	15:1, 21:1, 24:1, 30:1			15:1, 21:1, 24:1, 30:1		
4. Type of transmission	Herringbone			Herringbone		
5. Efficiency of transmission at full load, %	97	97	97	97	97	97
6. Type of thrust bearing	Spherical roller, self aligning					
7. Recommended drive hp.	3 to 10	7½ to 15	15 to 25	30 to 60	50 to 100	100 to 200
8. Screw speed range, r.p.m.	0 to 110 This range varies with applications	0 to 100	0 to 95	0 to 90 This range varies with applications	0 to 90	0 to 90
9. Maximum output of PE (Dens. – 0.92, MI – 2) at 400° F. and 2000 p.s.i., lb./hr.	50	90	140	310	580	950
10. Type of cooling system (cylinder)	Water/steam (forced air optional)					
11. Cooling system (hopper)	Water	Water	Water	Water	Water	Water
12. Safe operating head pressure, p.s.i.[1]	5000	5000	5000	5000	5000	5000
13. Materials of construction: a) For screw	Chrome molybdenum steel (also available: stainless steel, Dura nickel, Hastelloy)					
b) For barrel	Steel with centrifugally cast Xaloy liner					
14. Temperature controls, type	Proportioning type or saturable core reactor					
15. Type of heater	Mica band, cast in aluminum calrod, thermostrip					
16. Number of zones in barrel heater	2	3	3	3	4	4
17. Approx. heat-up time to 350° F., min.	15	20	20	25	30	30
18. Max. total heater wattage, kw.	10½	15½	22½	30	48	90
19. Venting and devolatilizing features available	Yes	Yes	Yes	Yes	Yes	Yes
20. Approx. delivery time, wks.	3 to 4	4 to 6	4 to 6	6	6 to 8	10

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[1] Assuming safety factor of 4.

JOHN ROYLE & SONS
PATERSON, N.J.

1.	½	1	1A	2	3	4	2A	3A	4A	5A	6A
2.	1-1/8	2	2½	3½		4½		6	8½	10	12
3.	27:1	24:1	24:1	20:1	22:1	18:1	20:1	20:1	15:1	14:1	14:1
			(ANY RATIO AVAILABLE)								
4.	Worm	Worm	Worm	Worm		Worm	Opp. Hel.	Opposed Helical			
5.	95	95	95	95		95	98	98	98	98	98
6.	Flat roller										
7.	10	15	25	40	60	75	125	200	300	400	750
8.	20-200	20-200	18-180	15-150	18-180	12-120	15-150	12-120	10-100	8-80	8-80
9.	50	125	165	250	350	600	750	1200	2100	3500	5200
10.	High velocity air and evaporative spray on all models										
11.	Passages for circulation of cooling medium on all models										
12.	10,000										
13. a)	Stainless steel with hardsurfaced lands on all models (Other materials available)										
b)	Forged steel with removable Xaloy liner (all models)										
14.	Proportioning type controllers on all models. Optional: "Dual-voltage" or "Power Match" control										
15.	Tubular resistance type on all models. "Spirod" radiant heat										
16.	Three cylinder zones standard; any number available										
17.	20			30				40		50	
18.	9	18	27	40	45	50	54	85	108	132	150
19.	Available in all models (complete with plug)										
20.	–	–	–	–		–		–	–	–	–

Price and delivery on customer request. ADDITIONAL INFORMATION: 1) Gear reducers are interchangeable between the various bore sizes; 2) Spirod radiant heat is efficient to temperatures of 1000° F.; 3) Controlled pressure extruders available for all applications.

(TWIN SCREW EXTRUDERS)
WELDING ENGINEERS, INC., NORRISTOWN, PA.

1. Model No.	2" Special	2" 2052-V1	2.8" 2852-V1	3.5" HH-3552-V2	3.5" 3500-DX	4.5" 4542-B	4.5" HH-4552-V1	6" 6052-V1	6" 6052-RV2
2. Nominal screw dia., in.	Two 2" screws		Two 2.8" screws	Two 3.5" screws		Two 4.5" screws	Two 4.5" screws	Two 6" screws	
3. L/D ratios available	20-42	25	25	25	42	20	25	25	25
4. Type of Transmission	Spur gear		Planetary				Planetary		
5. Efficiency of transmission at full load, %	94	94	94	92	92	92	92	92	92
6. Type of thrust bearing	Ball bearing		Spherical roller bearing						
7. Recommended drive hp.	10	10	25	75	50	100	150	300	300
8. Screw speed range, r.p.m., max.	150	150	150	150	150	150	150	150	150
9. Minimum output of PE (Dens. – 0.92, MI – 2) at 400° F. and 2000 p.s.i., lb./hr.	125	125	300	500	500	1000	1000	2000	2000
10. Type of cooling system (cylinder)	Water-cooled heat exchanger in oil circulation system								
11. Cooling system (hopper)	Jacketed Water Circulation								
12. Safe operating head pressure, p.s.i.[1]	2000	2000	2000	4000	2000	2000	4000	4000	4000
13. Materials of construction: a) For screw	Stainless Steel Stellited								
b) For barrel	Xaloy 306			Xaloy 306			Xaloy 306		
14. Temperature controls, type	Thermostat			Thermostat			Thermostat		
15. Type of heater	Hot oil circulation			Hot oil circulation			Hot oil circulation		
16. Number of zones in barrel heater	5-8	6	6	6	8	5	6	6	6
17. Approx. heat-up time to 350° F.	20	20	30	30	30	40	40	50	50
18. Venting and devolatilizing features available	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
19. Approx. delivery time, wks.	24	20	24	26	28	30	30	36	36

Assuming safety factor of 4. ADDITIONAL INFORMATION: All models are compounder extractor extruders. The 2 in. special is a lab test unit that can be assembled for various barrel lengths and types. Model 2052-V1 is a small vent lab or production unit. Models 2852-V1, 4542-B, HH-4552-V1, and 6052-V1 are small vent units; Model HH-3352-V2 is a large vent unit; Model 6052-RV2 is a large vent unit with "Hygrotrol" (patented adjustable pressure process); Model H3500-DX is an extra-large vent unit.

Screw type design: Full flighted, metering or a wide variety of special types.

Optional features: All types of variable speed drives, explosion-proof construction, quick opening dies, screening heads, strand dies, hot-cut pelletizing systems, special dies, and other features to meet customer requirements.

COVEMA, s.r.l., MILAN, ITALY
(U.S. REP.—RAINVILLE CO., INC., GARDEN CITY, L.I.)

1. Model No.	TR – 30	TR + 45	TR 60	TR – 80	TR – 100	TR – 120	TR 160
2. Nominal screw dia., in.	1-1/4	1-5/8	2-3/8	3-3/16	4	4-3/4	6-5/16
3. L/D ratios available	17:1	17:1-20:1	17:1-20:1	18:1-20:1	18:1-20:1	20:1	20:1
4. Type of transmission	V-belts			V-belts			
5. Type of thrust bearing	Conical roller type						
6. Recommended drive, hp.	2	4	8	16	30	40	80
7. Screw speed range, r.p.m.	6: 20-26-32-41-55-71-	6: 13, 5-17-23-29-35-44-	6: 7-14-25-33-36-45-	6	6	8: 6-10-12-14, 20-21, 26-38	15-30
8. Maximum output of PE (Dens.—0.92, MI—2) at 400° F. and 2000 p.s.i., kg.	3/8	8-25	25/30	40	20-100	50-130	130-300
9. Type of cooling system (cylinder)	Air or oil			Air or oil			
10. Cooling system (hopper)	Water-circulation			Water-circulation			
11. Materials of construction: a) For screw	Chrome/nickel steel heat-treated and ground						
b) For barrel	Spheroidal casting with liner in chrome/nickel steel heat-treated and ground						
12. Temperature controls, type	Stabilmatic			Stabilmatic			
13. Type of heater	Mica insulation type			Mica insulation type			
14. Number of zones in heater	2	2	3	2	2	2	2
15. Approx. heat-up time to 350° F., min.	20-30	30-40	30-40	40-50	50-60	60-70	70-90 80- 1.00 200
16. Max. total heater wattage, watts	2600	3650	5350	12,500	18,900	30,000	44,000
17. Venting and devolatilizing features available	Yes, on request			Yes, on request			
18. Approx. delivery time, wks.	Stock New York			Stock New York			

A. REIFENHAUSER MASCHINENFABRIK, TROISDORF, GERMANY (U.S. REP.—HEINRICH EQUIP. CORP., NEW YORK, N.Y.)

1. Model No.	S-30	S-45	S-60	S-90	S-120	S-150
2. Nominal screw dia., in.	1¼	1¾	2½	3½	4½	6
3. L/D ratios available	15 : 1 20 : 1	20: 1	20: 1 and 25: 1	20: 1 and 25: 1	20: 1 and 25: 1	20: 1 and 25: 1
4. Type of transmission	Hardened and ground herringbone					
5. Efficiency of transmission at full load, %	–	–	–	–	–	–
6. Type of thrust bearing	Spherical roller					
7. Recommended drive, hp.	3	6/7	15-30	30-50	75-85	125-145
8. Screw speed range, r.p.m.	26-120	3-81	8: 1 ratio	10:1 ratio	10:1 ratio	10:1 ratio
9. Maximum output of PE (Dens. – 0.92, MI – 2) at 400° F. and 2000 p.s.i., lb./hr.	5-20	10-50	75-150	200-300	450-600	600-800
10. Type of cooling system (cylinder)	Air-water spray			Air-water spray		
11. Cooling system (hopper)	Air-water spray			Air-water spray		
12. Safe operating head pressure, p.s.i.[1]	Max. 8000	Max. 8000	Max. 8000-10,000	Max. 8000-10,000	Max. 10,000	Max. 10,000
13. Materials of construction: a) For screw	High-grade alloy, surface hardened and super polished					
b) For barrel	Xaloy and Xaloy 306					
14. Temperature controls, type	West or Wheelco					
15. Type of heater	Resistance band		Resistance band or induction			
16. Number of zones in heater	15 : 1 - 3 20 : 1 - 4	20 : 1 - 4	20 : 1 - 4 25 : 1 - 5	20 : 1 - 4 25 : 1 - 5	20 : 1 - 4 25 : 1 - 5	20 : 1 - 4 25 : 1 - 5
17. Approx. heat-up time to 350° F., min.	30-60	30-60	30-60	30-60	30-60	30-60
18. Max. total heater wattage, kw.	3-4	6	10-12.5	16-20	20-24	25-30
19. Venting and devolatilizing features available	No	Yes	Yes	Yes	Yes	Yes
20. Approx. delivery time, Wks.	12	(In U. S. and Canada only) 12	12	12	12-16	16

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[1] Assuming safety factor of 4.

ADDITIONAL INFORMATION: Model S-45 equipped with floating screw adjustment; Model S-60 equipped with hydraulic floating screw adjustment and interchangeable reduction gears; Model S-120 equipped with hydraulic floating screw adjustment and interchangeable gear sets; Model S-150 equipped with interchangeable gear sets.

	FRANCIS SHAW AND CO., LTD., MANCHESTER, ENGLAND							KATO SEISAKUSHO CO., LTD., TOKYO, JAPAN
1.								KE-75a
2.	1	1½	2	3	4½	6	8	75 m/m
3.	–	–	–	–	–	–	–	15: 1, 19: 1
4.	Positive direct drive through reduction box	Herringbone reduction gears						Spur & double helical gear use
5.	–	–	–	–	–	–	–	85
6.	–	–	–	–	–	–	–	Ball
7.	1¼	5	13.5	20	60	80	120	10
8.	120	80	80	80	80	80	80	16, 24, 36, 55 Motor Revolution 1500
9.	–	–	–	–	–	–	–	35 Kg./hr.
10.	Axial blower (optional)	Axial blower[1] (optional)						Water
11.	–	–	–	–	–	–	–	Water
12.	–	–	–	–	–	–	–	–
13. a.	–	–	–	–	–	–	–	–
b.	Nitralloy steel with honed bore							–
14.	Capillary	Proportioning electronic type						Auto-trans system
15.	Sealed vapor pressure system			–	–	–	–	Elec.; wire heater
16.	2	–	3	3	4	4	4	4
17.	–	–	–	–	–	–	–	–
18.	Band heaters, 4 @ 300 w. each	Resistance heaters 4 @ 300 w. each	4 @ 750 w. each	6 @ 1100 w. each	6 @ 1100 w. each	8 @ 3350 w. each	4 @ 8000 w. each; 4 @ 6000 w. each	7
19.	–	–	–	–	–	–	–	–
20.	–	–	–	–	–	–	–	8

FRANCIS SHAW: [1] Can be made to operate automatically in conjunction with heaters.

ADDITIONAL INFORMATION: On all models, the following equipment is available: Type of head clamp – quick release taper clamps; type and capacity of hopper – square feed pocket tangential to screw; extras – straight-through die heads for miscellaneous sections, right-angle heads for wire covering. The 1 in. model is available with constant speed induction motor and "H" variable speed gear; all other models are available with A.C. variable speed motors with 4/1 speed variation or constant speed induction motor and Carter variable speed gear (1½ in. model) or constant speed induction motor and H and F dynamic slip coupling (2, 3, 4½, 6, and 8 in. models) or Ward Leonard V.S. 4/1 drive (6 and 8 in. models).

EXTRUDING MACHINES	**NEGRI BOSSI AND CO., MILAN, ITALY**						**PECO MACH. SALES, LTD., LONDON, ENG.**	
1. Model No.	NB 60 Master	NB 75 Master	NB 90 Master	NBV 45 Master	NBV 60 Master	NBV 75 Master	25	45
2. Nominal screw diameter, mm.	60	75	90	45	60	75	2½ in.	4½ in.
3. L/D ratios available	18:1	18:1	18:1	18:1	18:1	18:1	11:1; 16:1, 21:1	16:1
4. Type of transmission	Gear box			Speed variator			Multiple V-belt and Worm	
5. Efficiency of trans. at full load, %	–	–	–	–	–	–	95 (over-all)	
6. Type of thrust bearing	Ball bearing			Ball bearing			Flat roller	
7. Recommended drive, hp.	8	14	22	5	8	14	20	50
8. Screw speed range, r.p.m.	12-17-23 30-40-55	12-17-23 30-40-55	11-15-20 26-34-45	15 to 60	15 to 60	15 to 60	12-100	–
9. Max. output at PE (Dens. -0.92; MI-2) at 400° F. and 2000 p.s.i., lb./hr.	24-88	39-121	44-154	13-64	24-97	39-132	120	350
10. Type of cooling system (cylinder)	Optional by air			Optional by air			Water (Auto.)	
11. Cooling system (hopper)	Water	Water	Water	Water	Water	Water	Water (Manual)	
12. Safe operating head pressure, p.s.i. [1]	–	–	–	–	–	–	–	–
13. Materials of construction: a) For screw	Heat-treated chrome-nickel steel						LK 3 Stainless steel	
b) For barrel (liner)	Heat-treated chrome-nickel steel						–	–
14. Temperature controls, type	Stablimatic			Stablimatic			Wheelco	
15. Type of heater	Heater band			Heater band			Resis. heater	
16. No. of zones in barrel heater	5	5	5	4	5	5	3	3
17. Approx. heat-up time to 350° F., min.	–	–	–	–	–	–	–	–
18. Max. total heater wattage, kw.	6	8.5	12	3.5	6	8.5	9	28.5
19. Venting and devolatilizing features available	–	–	–	–	–	–	No	No

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[1] Assuming safety factor of 4.

	JOHANN FISCHER MACHINE CO., LOHMAR, WEST GERMANY, (U.S. REP.: BARCLAY INDUSTRIES, INC., NEW YORK, N.Y.)									R. H. WINDSOR LTD., CHESSINGTON, SURREY, ENGLAND	
1.	JFP 32	JFP 50	JFP 60	JFP 45		JFP 60		JFP 90		3½ SS	4½ SS
2.	1¼ in.	2 in.	2½ in.	1¾ in.		2½ in.		3½ in.		3½ in.	3½ in.
3.	15:1	15:1	15:1	20:1	25:1	20:1	25:1	20:1	25:1	20:1	20:1
4.	PIV gear		PIV gear			Commutator motor				Hydraulic	
5.	–	–	–	–		–		–		–	–
6.	Axial ball bearing	Axial pendulum roller bearing								–	–
7.	3	7.5	10	7.5	15	20	30	37	45	40	50
8.	25-110	18-81	16-72	18-81	18-67	18-67		17-76	18-67	10-90	10-80
9.	4.5-22	13-66	22-90	18-90	22-110	11-150	45-220	78-330	100-440	250/300	300/350
	(Dependent on material and cross-section)										
10.	Water cooling system			Water cooling system for 20:1 Air cooling system for 25:1						Air	Air
11.	Water	Water	Water	Water		Water		Water		–	–
12.	–	–	–	–		–		–		–	–
13. a)	Nitrodur 80		Nitrodur 85	Nitrodur 80		Nitrodur 85	Nitrodur 80	Nitrodur 85		Nitralloy	
b)	Nitrodur 80		Nitrodur 85	Nitrodur 80		Nitrodur 80	Nitrodur 85	Nitrodur 85		Nitralloy	
14.	Norfa controller			Norfa controller						4 Controlling pyrometers	5 Controlling pyrometers
15.	Electric heating elements									Induction	Induction
16.	3 (cylinder zones) 3-6 (head zones)		3 (cyl.) 3-5 (head)	3 (cylinder zones) 3-6 (head zones)				4 (cyl.) 4-7 (head)	3 3-6	4	5
17.	60	60	60	60		60		90	120	–	–
18.	3	3.9	3.9	6.5	3.9	13	7.5	30	25.5	24	35
19.	–	–	–	–		–		–		–	–

ADDITIONAL SUPPLIERS

INJECTION MOLDING MACHINES

ACME MACHINERY MFG. CO., INC., Yonkers, N.Y. – "...distribute De Mattia 4/6 and 12/16 oz. injection molding machines."

BATTENFELD MASCHINENFABRIKEN GMBH, Meinerzhagen, W. Germany (U.S.: Battenfeld Corp. of America, Chicago, Ill.) – "...injection molding machines from 1/10 oz. upwards... with screw plasticizing unit, 350 ounces."

COSTRUZIONI MECCANICHE s.r.l., Bresso (Milan), Italy (World dist.: COVEMA, Milan, Italy) – "...make available the G.B.F. Plastiniector in 2, 4, 6, 11, and 18 oz. capacities. Preplasticizers... fast injection speed... automatic operation cycle regulated by timers and continuously controlled... hourly plasticizing capacity for the 2 oz. machine is 20 lb.; for the 4 oz., 30 lb.; for the 6 oz., 49 lb.; for the 11 oz., 88 lb.; for the 18 oz., 145 pounds."

DANIELS, T. H. & J., Gloucestershire, England – "...also supply injection molding machines."

JOHNSON MACHINERY CO., Newark 5, N. J. – "...distributors of injection molding machines."

KATO SEISAKUSHO CO., LTD., Tokyo, Japan – "...supply injection molding machines."

RAINVILLE CO., INC., THE, Garden City, N.Y. – "...distribute injection molding machines."

SHAW, FRANCIS, & CO., LTD., Manchester, England – "...also manufacture a small type injection molding machine."

COMPRESSION MOLDING MACHINES

ADAMSON UNITED CO., SUBSIDIARY OF UNITED ENGINEERING AND FOUNDRY CO., Akron, Ohio – "...designers and builders of all sizes of compression and transfer molding presses from 50 tons up."

BATTENFELD MASCHINENFABRIKEN GMBH, Meinerzhagen, W. Germany (U.S.: Battenfeld Corp. of America, Chicago, Ill.) – "...compression and transfer molding presses up to 300 tons capacity."

BECKER & VAN HULLEN, Krefeld, West Germany – "...manufacture a complete line of platen presses, forming presses, reinforced plastics presses, laboratory presses, and hydraulic injection molding machines. Also make available an automatic press installation with loader and unloader for the manufacture of plastics laminates."

BOLLING, STEWART, & CO., INC., Cleveland, Ohio – "...major manufacturer of hydraulic presses that cover a wide range of stroke and ram sizes and pressure ratings. Basically, the company supplies compression and transfer molding presses in a range from 50 to 2000 tons pressure and a size range from 12 by 12 in. to 50 by 100 inches. The three types of presses manufactured are: 1) four-rod type; 2) slab-side type; and 3) full ring type for extremely high pressures."

ERIE FOUNDRY CO., Erie, Pa. — "...supply transfer and compression molding presses. Typical specifications for a 200-ton unit follow: operating pressure — 2550 p.s.i.; opening w/o bolsters — 38 to 50 in. (adj.); main ram diameter — 13 in.; transfer ram diameter — 7½ by 5½ in.; platen — 30 by 24 in.; stroke, main ram — 15 in.; stroke, transfer — 15 in.; advance speed — 270 in./min.; return speed — 240 in./min.; press speed — 19 in./minute."

JOHNSON MACHINERY CO., Newark, N. J. — "...distributors of hydraulic presses."

KNUTH ENGINEERING CO., Chicago, Ill. — "...supplies the K&K laboratory press... when hot and cold plates have been added to the press, it can be used for laminating and forming plastics... has been adopted by fabricators for research and development or for small pilot runs for testing purposes. Specifications: width — 8 in.; depth — 8 in. (front to back); height (high setting) — 16 in.; height (low setting) — 12 in.; lift (piston travel) — 7 in.; rated pressure — 6000 lb.; gage (round dial, 200 lb. intervals) — 10,000 pounds."

LAKE ERIE MACHINERY CORP., Kenmore, N. Y. — "...custom build large compression machines."

LAWTON, C. A., THE, De Pere, Wis. — "...reinforced plastics molding press... hydraulic compression and transfer press... C-frame... air hydraulic... metal draw."

LODGE & SHIPLEY CO., THE, Cincinnati 25, Ohio — "...supply Columbia compression molding presses engineered for a particular job and built of standard components to provide a custom unit. Typical range of specifications; platen sizes — from 12 by 12 in. to 36 by 36 in.; ram diameter — from 10 to 18 in.; total pressure — from 100 to 300 ton; closing speed — from 68 to 90 in./min.; compression speed — from 1.8 to 5.9 in./min.; opening speed — from 60 to 75 in./minute."

M & N HYDRAULIC PRESS CO., Clifton, N. J. — "...supply a line of hydraulic molding presses (column type) in a wide range of sizes. Typical range of specifications; capacity — from 25 to 300 tons; stroke (max., power return) — from 8 to 12 in.; stroke (max., gravity) — from 8 to 12 in.; speed (IPM up, approx.) — from 23 to 60; press at full load (approx.) — from 1½ to 12 in.; operating pressure — from 2500 to 3000 p.s.i.; platen size — from 12 by 12 in. to 14 by 30 in.; daylight (minimum) — from 8 to 30 in.; daylight adjustment (INS.) — from 10 to 18 inches. Hand-operated, semi-automatic, and fully automatic controls... special "V" packed ram... available with power or gravity return platen... pressure regulator... adjustable crown... single or multiple platens... rapid speed advance stroke with adjustable automatic slowdown."

NEW ENGLAND BUTT CO., Div. of Wanskuck Co., Providence, R. I. — "...automatic rotary plastic molding presses... 10- or 30-station machines... fully automatic compression molding... hopper feed (the supply rotates)... adjustable production cycle... adjustable temperature in mold holders."

RAINVILLE CO., INC., THE, Garden City, N. Y. — "...distribute compression molding presses."

VERSON ALLSTEEL PRESS CO., Chicago, Ill. – "...manufacturers of specialized equipment in large tonnage capacities, engineered for the job requirements."

WOOD, R. D., CO., Philadelphia, Pa. – "...manufacturers of special compression and transfer molding presses to order."

EXTRUDING MACHINES

ACME MACHINERY MFG. CO., INC., Yonkers, N. Y. – "...distribute Negri Bossi extruding machines with American controls."

BAKER PERKINS, INC., Saginaw, Mich. – "...manufacture a specialized small auxiliary extruder for use with continuous Ko-Kneader mixers."

BATTENFELD MASCHINENFABRIKEN GMBH, Meinerzhagen, W. Germany (U. S.: Battenfeld Corp. of America, Chicago, Ill.) – "...extruders and complete automatic plants (with screw diameters of 1¼, 1¾, 2½, 3½, and 6 inches."

BERSTORFF, HERMANN, MASCHINENBAU, Hannover, Germany – "...Type K200 extruder with laminating unit for laminating plastics to paper, textiles, and plastics films...high working speeds (about 110 yd./min. in widths up to 78 inches)."

CHANDLER EQUIPMENT CO., Anaheim, Calif. – "...self-contained extruders completely wired with motor, motor starter, and all electrical components."

RAINVILLE CO., INC., THE, Garden City, N. Y. – "...distribute extruding machines."

THERMOPLASTIC EQUIPMENT CORP., Stirling, N. J. – "...two-color vertical extruder...can be used by itself or in tandem with standard extruders for jobs where contrasting color effect is desirable."

WAYNE MACHINE & DIE CO., Passaic, N. J. – "...manufacture small laboratory extruder."

WERNER & PFLEIDERER CORP., Stuttgart, Germany (U. S. office – New York, N. Y.) – "...twin-screw devolatilizing dispersion extruder type ZSK 83/700."

FOR NAMES AND ADDRESSES OF COMPANIES LISTED AND FOR COMPLETE RUNDOWN OF MANUFACTURERS AND DISTRIBUTORS OF THE VARIOUS PROCESSING UNITS COVERED, SEE THE DIRECTORY INDEX, p. 1078.

Temperature measurement and control

By Richard A. Wade*

In plastics processing, there is an application for every known type of temperature sensing element. Most processors use thermocouples, yet other transducers are superior to thermocouples for many purposes. Where, when, and —more important—how to use other temperature transducers often poses a problem. Sensitivity, accuracy, range, speed of response, expected useful life, cost, and adaptability to various modes of automatic control are only a few of the factors in the selection of temperature measuring equipment.

The five most common sensing elements are: 1) Filled thermal systems. 2) Thermocouples. 3) Resistance bulbs. 4) Thermistors. 5) Radiation pyrometers.

Filled thermal systems

Filled thermal systems operate on the principle that heat causes expansion and cold causes contraction. There are two fundamental types, both based on the invention of the Bourdon spring: 1) those in which the Bourdon responds to volume changes; and 2) those in which it responds to pressure changes. The first type is completely filled with a liquid. The second is either filled with a gas or partially filled with a volatile liquid. The principle of a vapor filled thermal system is shown in Fig. 1, right, in which the spiral represents the Bourdon spring and the airtight container represents the bulb.

Filled thermal systems are extremely simple in design. This results in low initial cost and generally minor upkeep, perhaps the main advantage in using them. They have sufficient power to drive a controller mechanism as well as a recording pen. Controllers may have all modes of pneumatic control, multiposition electric control, and integral cam-type cycle programming. Accuracy is usually ±1% of instrument span, and sensitivity about ¼% of instrument span. The shortest spans (around 25° F.) are available in liquid filled systems; however, special liquid filled systems have been designed with spans as narrow as 10° F. While filled systems and mechanical instruments are less expensive than electrical measuring systems, they are not as sensitive or as accurate as their short span electrical counterparts.

Although the accuracy and sensitivity of filled systems are generally acceptable to the plastics industry, the relatively large size of their thermal bulbs is perhaps the main deterrent to their use. The smallest bulbs are made for liquid filled systems, but even these are at least ¼ in. O.D. by 1¼ in. long. Short spans are desirable for greater accuracy of measurement, yet the shorter the span, the larger the bulb.

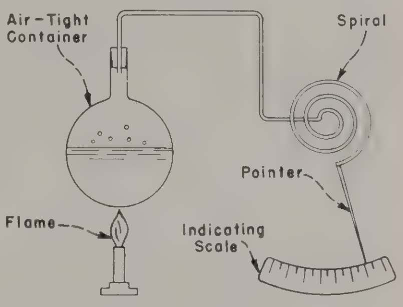

FIG. 1: Principle of the vapor filled thermal sensing system

A second objection to thermal systems is the lack of electrical control modes available for the controlling instrument. Processes which require electric control and also have large load changes need more than a multiposition mode of control.

Most filled systems are used to measure the temperature of fluids, but there are applications where they can infer the temperature of a solid and promote excellent control. A typical application is controlling the steam and cooling water to platen presses for compression molding. In this case, there is a long dead time between the time a valve changes the flow of the heating or cooling medium and the time that the corrective temperature change begins to take place in the mold. To circumvent the dead time, two instruments can be connected to form a cascade control loop. The mold temperature is measured by a thermocouple and a program controller. The pneumatic control signal from the program controller repositions the set point index on a thermometer controller. The bulb of the filled system is placed in the steam and water mixing line. The pneumatic signal from the thermometer controller operates valves in the steam and cooling lines. This cascade control system might be regarded as a means of storing potential energy to meet the rapidly changing demands of the mold. Cascade control loops such as this circumvent the problem of dead time, reduce cycle time, and generally improve product quality by reducing temperature cycling in the mold.

This example of cascade control illustrates that: 1) within a given control system it is often desirable to use more than one type of temperature sensing element; and 2) filled systems are primarily employed when the heating medium is a fluid. In general, where pneumatic control can be used, and there is enough room to install a ½ in. O.D. by 3½ in. bulb, consider a filled thermal system.

Thermocouples

A thermocouple consists of two wires of dissimilar metals joined at either end, usually by welding. This transducer produces a voltage which is proportional to the temperature difference between the measuring junction (inserted into the process) and the reference junction (the point where the ex-

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*Application engineer, Rubber and Plastics Industry, Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Philadelphia 44, Pa.

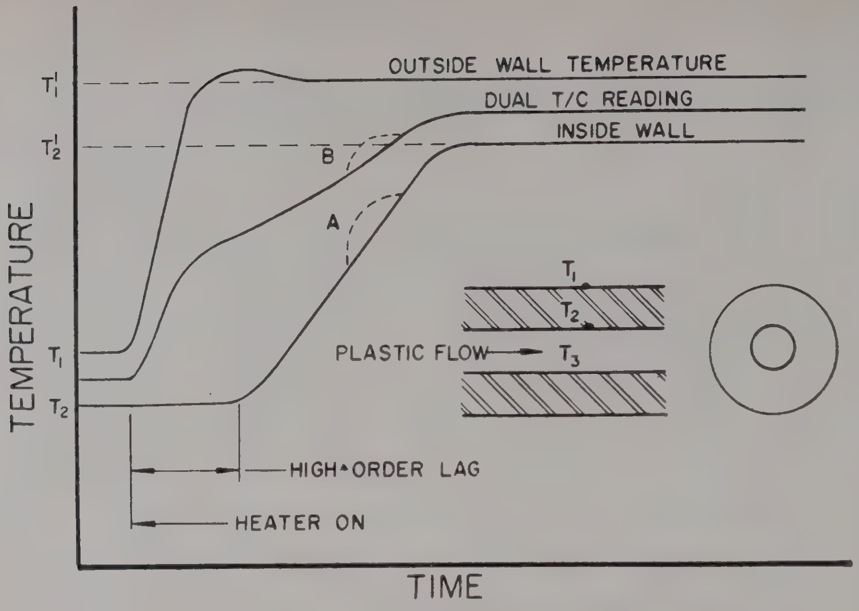

FIG. 2: High-order lags can be avoided by dual thermocouples. Drawing at right center gives analogy; curves show temperature relationships

tension wires are connected to the measuring instrument).

A frequent control problem in plastics processing arises because of high-order lags due to heat transfer through a series of mediums. Cycling around the set point is the result. While it is true that more sophisticated controllers alleviate the problem, the weakest link in the control loop is often the sensing element.

High-order lags can be illustrated by considering a steel tube with a heating medium on the outside surface and a plastic flowing through the inside, as shown in Fig. 2, above. An analogous situation is found in extruders, injection molding machines, and many plastic molds. Although the specific heat of the plastic may be three or four times that of the metal, there is generally 100 to 1000 times more metal than plastic. To obtain a given temperature change in the plastic, time is consumed in changing the temperature of the metal. Thermocouples located near the heating medium offer good heat input control, but give a poor indication of melt temperature. Conversely, thermocouples located deep in the cylinder wall give a good indication of melt temperature, but poor heating control. The shallow thermocouple would promote satisfactory control if load changes did not occur inside the tube, but changes in the molecular weight of the plastic and increased frictional heat, due to changes in flow rate, rule this out.

Fortunately, two thermocouples in parallel offer the advantages of both deep and surface thermocouples without inheriting the disadvantages of either. By making the resistance of both thermocouples equal, the potential across the measuring instrument is proportional to the average of the voltages developed by the two junctions. To obtain a true average temperature reading: 1) all thermocouples must have the same resistance; 2) all thermocouples must be connected directly to the two common terminals at which the net emf is measured; and 3) the thermocouple voltage must vary linearly with temperature in the region of the measurement.

Dual thermocouples add what might be called a form of rate and proportional action to the control loop. In essence, the signals from the dual thermocouples fool the controller. Figure 2 shows the relationship between outside wall temperature and inside wall temperature, and the dual thermocouple reading for a temperature step change in the heating medium (as occurs when an extruder's electric heaters are turned on). When the temperature of the heating medium increases, the magnitude of the dual thermocouple reading is weighted by the rapid rise of the outside surface temperature. Conversely, in cooling, the reading of the dual thermocouples is weighted by the slow change in the melt temperature.

The response of the dual thermocouples to a temperature change either at the surface or in the melt is rapid. As soon as the temperature of the heating medium is changed, the thermocouples begin to respond. This would not be true with one deep thermocouple. When the heat generation on the inside of the tube changes, as shown by A in Fig. 2, the thermocouples again respond immediately. Such a fluctuation might not be detected by a shallow thermocouple due to damping, and at best would appear only after a substantial time interval. It is important to note, however, that the magnitude of a temperature change, either inside or outside the tube, is reduced by a factor of two when read by dual thermocouples.

This example illustrates that it is not always best to measure the *controlled variable* to obtain successful control. In the above case, even a complete temperature profile of the plastic melt would not help the control problem. The lags due to heat transfer would still exist. On the other hand, limiting the B.t.u. input per unit surface area per unit time (watt density in electric heaters) and minimizing the measuring instrument dead band does help the control problem. The former minimizes the external load changes, and the latter improves the sensitivity of the controller. Optimum controllability would be obtained when the process is run adiabatically and the flow rate and back pressure on the plastic control the heating. However, the main point to remember is that the type, placement, and configuration of the sensing element are as important to the control problem as the control mode in the instrument.

Resistance thermometers

Resistance thermometers relate changes in the temperature of an electrical conductor to a proportional change in electrical resistance. Industrial units of this type are usually accurate to ±0.5° F. in a 32 to 212° F. range.

Laboratory models are available for measurements reproducible within ±0.01° C. or 0.002% of their working span. In addition, these transducers are available with high speeds of response (time constants of 0.05 sec. for open pickups and 0.005 sec. for wafer-type elements). As with thermocouples, speed of response depends upon the ratio of thermal capacity to thermal conductance. Since thermal capacity is related to mass, while thermal conductance is proportional to surface area, the mass/area ratio becomes important in obtaining high speeds of response. Of course, the type of protecting well and the type and velocity of the measured medium are extremely important to the overall response of the resistance thermometer. In general, with resistance thermometers it is possible to obtain higher speeds of response and greater accuracy than with thermocouples.

Perhaps the main reason for not using resistance thermometers in the plastics industry is their relatively large size. The smallest sensing bulbs are about ¼ in. O.D. by 2 inches. Although mold temperatures might be controlled very closely with these devices, the size often prohibits their use. For the majority of plastics processing control problems, the accuracy and speed of response of thermocouples are satisfactory and, furthermore, thermocouples are usually much smaller than the equivalent resistance bulbs.

The wafer-type resistance thermometer, however, may not have had the use that it merits. Wafer sensing elements can measure surface temperatures with high accuracy and extremely fast speeds of response. A typical element is 0.005 in. thick, 0.5 in. wide, and 1.5 in. long. In molds for injection molding machines, such a device should fit nicely in shallow indentations between the two cavity retainer plates. Mounting a wafer bulb is much like mounting a wafer strain gage, except that the temperature bulb should not be mounted on a free moving piece or in a place where the wires would be subjected to stresses and strains.

In the plastics industry today, resistance bulbs are used mainly in research, where close and accurate temperature measurements are required. However, the future will probably see a wider use of the wafer type resistance bulb in processing work.

Thermistors

Thermistors are solid-state devices similar to resistance thermometers, but are made from semiconductors rather than conductors. The pure metals used in wire-wound resistance bulbs *increase* in resistance with a temperature rise. This is because electron-mobility is reduced due to a decreased mean free path. Semiconductors *decrease* in resistance with temperature rise due to the increased availability of electrons from the break-up of covalent bonds. The available electron changes in semiconductors are very great so that temperature-resistance coefficients, while negative, are much greater than for metals.

Because of their high temperature-resistance coefficients, thermistors are used with narrow span instruments to provide exceptionally close control. With an instrument having 10° F. span and ¼% accuracy, measurement to ±0.025° F. is possible.

More important to the plastics industry is that thermistors are small. Some thermistors are as tiny as the head of a pin, and the protecting well for this element is often as small as a piece of pencil lead. The size of three industrial thermistors is compared with a king size cigarette in Fig. 3. Their size makes thermistors ideal for mounting in molds and other areas requiring close tolerances.

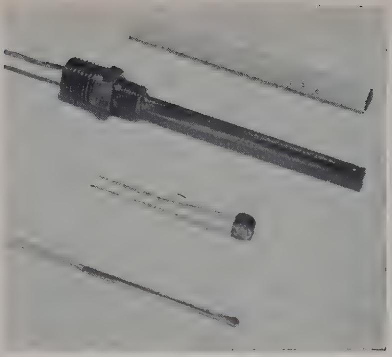

FIG. 3: Thermistors are smallest available temperature transducers. Three (one in protecting well), are here compared for size with king-size cigarette

A thermistor and a thermocouple can be housed in the same protecting well. The thermocouple signal can be used to bring the particular process up to temperature, within control limits of roughly ±2 to 5° F. At this point, the controlling instrument can be switched to read the thermistor signal. What was once an 800° F. span on an extruder could become a 20° F. span, and control accuracy could be ±¼° F. Today, this arrangement would require two instruments because of the negative temperature coefficients of most thermistors. However, semiconductor devices with positive temperature coefficients have recently been developed, and it appears that in the near future control will be obtained with only one instrument. The thermocouple-thermistor combination operates well on continuous processes, such as extrusion, where close temperature control over extended periods of time is required. Where process dead-time is negligible, this combination may also be used in cyclic processes such as mold temperature control in injection molding. In this instance, the control instrument automatically switches from the wide span to the narrow span.

Since thermistors are relatively new devices, many improvements must be made before they will enjoy widespread usage. Currently, the greatest objection to thermistors is their relatively poor stability. Long-term stability of the resistance-temperature relation depends upon thermistor con-

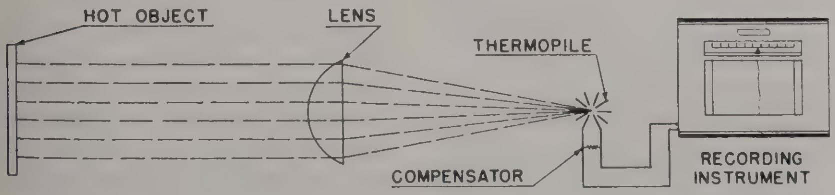

FIG. 4: Principle of operation of the radiation pyrometer

struction, use, and conditions. If subjected to cycling at a high temperature, some thermistors may exhibit a behavior characteristic of relaxation. The resistance change may be several percent following the temperature change, with a recovery time of a few hours. When thermistors are held at a fixed temperature with negligible current flow, resistance changes on the order of 1% per year are typical. The drift of a thermistor decreases with aging, so new thermistors must be preaged before installation. However, as new materials are developed, the stability of thermistors is being improved. Within the near future, thermistors with stability characteristics good enough for plastics industry use should be commercially available.

Radiation pyrometers

The radiation pyrometer is a transducer which measures the intensity of radiation emitted by an object over a wide band of wavelengths. This radiation is focused by a lens, or aperture, on a resistance thermometer, thermocouple, or a series of thermocouples known as a thermopile. Fig. 4, p. 941, shows the principle of operation of the radiation pyrometer. All bodies above absolute zero emit radiation which varies with the temperature of the body. Once this radiant energy is focused on the sensing element, the operation of the radiation pyrometer is much the same as the operation of a thermocouple or resistance thermometer.

The performance of a radiation pyrometer can be predicted by basic laws of optics. Fortunately for the plastics industry, opaque plastics generally have high emissivities; that is, they absorb and emit a large percentage of the incident radiation. Transparent plastics have high emissivities in at least one narrow band of the infra-red spectrum. With a little care, the radiation pyrometer can measure the temperature of most plastics, even clear films as thin as one mil.

Although radiation pyrometry was once restricted to high-temperature measurements, this is no longer true. Industrial instruments are available which successfully operate at temperatures as low as 125° F., and, on special applications, 40° F. can be measured. A radiation pyrometer has two advantages: 1) the temperature sensing device does not physically touch the measured medium, and 2) the instrument has a fast speed of response, usually less than ½ second. The radiation pyrometer is ideal for temperature scanning purposes in film production, for following the progress of epoxy curing, and for temperature measurements in drape forming.

For most applications in the plastics industry, a low-range radiation pyrometer is used. The normal limits of temperature measurement for this device are roughly 125 to 700° F. Unfortunately, it is impractical to factory-calibrate the instruments in terms of degrees Fahrenheit, and usually a 0 to 100 scale is supplied. This should not bother process men, since all temperature scales are relative, and the control system functions independently of the numbers on the scale. All modes of control, both pneumatic and electrical, are available in instruments used with radiation pyrometers. The chief practical limitation is the 350° F. ambient temperature to which the detecting head can be subjected. Where existing ambient temperature is higher, the head must be water or air cooled. There are also a number of optical considerations in applying the radiation pyrometer; usually it is advisable to discuss the anticipated application with the equipment manufacturer.

AUTHOR'S NOTE: All we hope to achieve by this article is to give you some idea of the types of temperature transducers available. We've avoided going into too much technical detail about any one device. Selecting the correct transducer for a given job requires some knowledge of control theory. In this area, a little knowledge can be more harmful than none at all. Such control problems as "dead-time" and "high-order lags" must be clearly understood. So before you decide on a specific transducer, check through the following references. They will increase your understanding of these problems and help you select the correct transducer for a successful system.

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EQUIPMENT FOR COATING

By D. G. Higgins*

The art of coating may be defined as the controlled application of a mobile, film-forming material to a web or sheet. Thus, coatings may be applied at a plastic calender, at an extrusion unit, or by use of a paint brush. The equipment used can be divided into the type which premeters the coating prior to application to the web, and the type which applies an excess of coating and then removes a portion.

The premetered coating processes may be separated as follows: a) calender coating; b) extrusion coating; c) kiss-roll coating; d) reverse-roll coating; e) spray coating; f) engraved-roll or gravure coating; and g) cast coating.

The postmetered coatings may be classified as follows: a) knife scraper, either floating, on roll, on blanket, or opposed knives; b) squeeze- or pressure-roll metering; and, c) air-blade metering.

Following any of the coating processes, there are auxiliary surface treatments to improve the uniformity of the coated finish and to remove coating irregulari-

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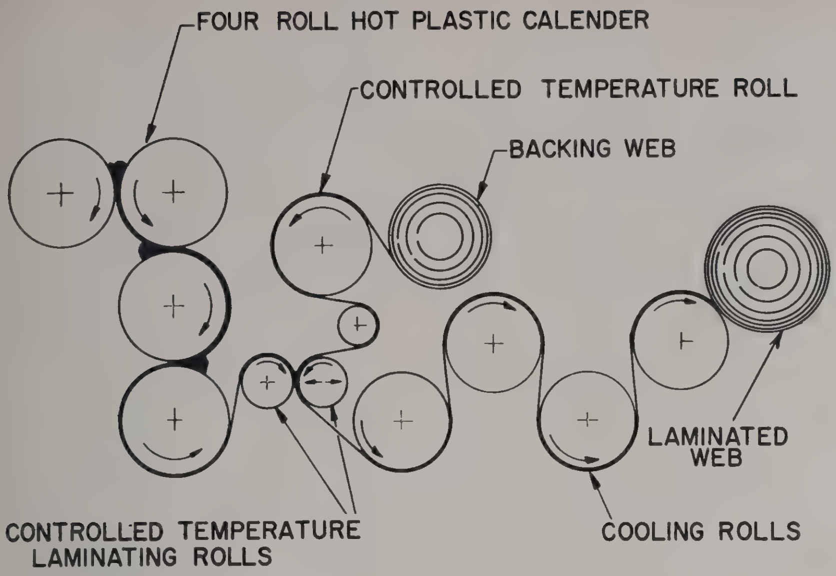
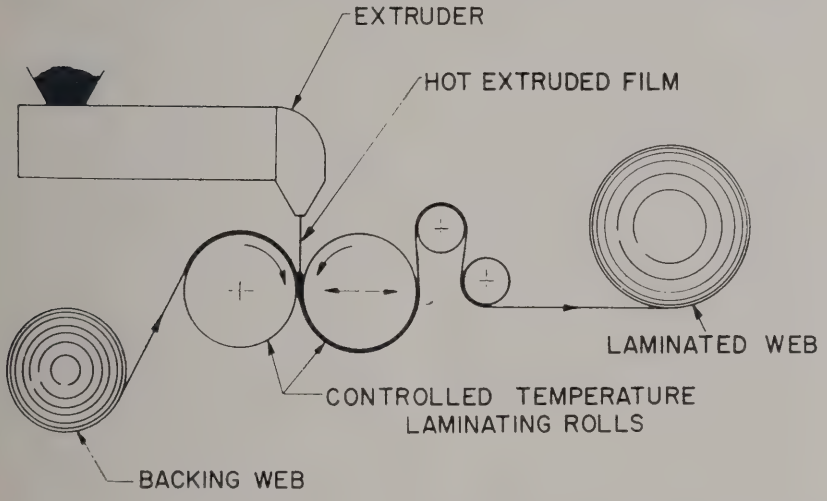
*Sales mgr., John Waldron Corp., Subs., Midland-Ross Corp., P. O. Box 791, New Brunswick, N. J.

References were prepared by the editors.


FOUR ROLL HOT PLASTIC CALENDER
CONTROLLED TEMPERATURE ROLL
BACKING WEB
LAMINATED WEB
CONTROLLED TEMPERATURE LAMINATING ROLLS
COOLING ROLLS

COATING by four-roll system of post-calender lamination.

EXTRUSION COATING of hot film on backing web



ties. These may be noted as follows: a) flexible trowel or smoothing blade; b) brushes, either rotating or oscillating; and c) spinning smoothing rolls.

Premetered coatings

Calender coating: In this process, the web to be coated may be passed through the bottom nip of the calender-roll stack to receive the plastic coating either with or without final coating metering at this nip. The alternate process of calender coating is actually a post-calender type of lamination handled at auxiliary pressure rolls.

Extrusion coating: Melted thermoplastic resin is extruded through a slit die into the nip of a pair of cooling and laminating rolls with a web of paper, foil, or plastic, etc. The width of die opening, and the speed of the laminating nip, control the thickness of coating.

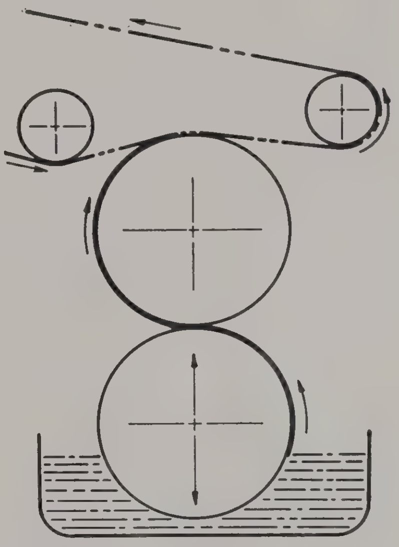
Kiss-roll coating: This roll arrangement carries a metered film of coating to the web; at the line of web contact it is split with part remaining on the roll, the remainder adhering to the web.

Reverse-roll coating: This is the most versatile of all coating units. The coating is premetered between rolls and then wiped off on the web. The amount of coating is controlled by the metering gap and also by the speed of rotation with which the coating roll will revolve.

Spray coating: Spray coatings on continuous webs are usually applied by a set of reciprocating spray nozzles travelling laterally across the web as it moves. An alternate spray pattern on the moving web is sometimes accomplished by moving the spray nozzles in a circular path directly above the web of material as it travels along.

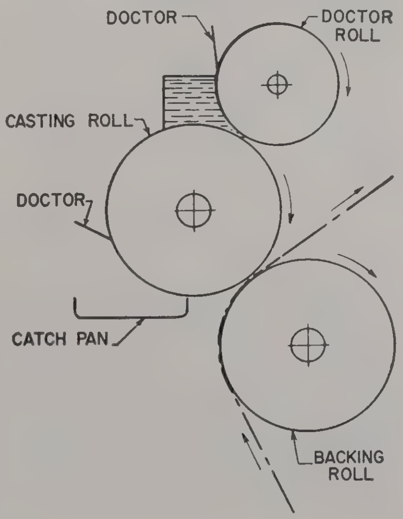
Engraver-roll or gravure coating: In this process, the amount of coating applied to the web is metered by the depth of the overall engraved pattern in a print roll. This process is frequently modified by interposing a resilient roll between the engraved roll and the web. This is an offset roll and tends to obliterate any engraving pattern in the coated surface.

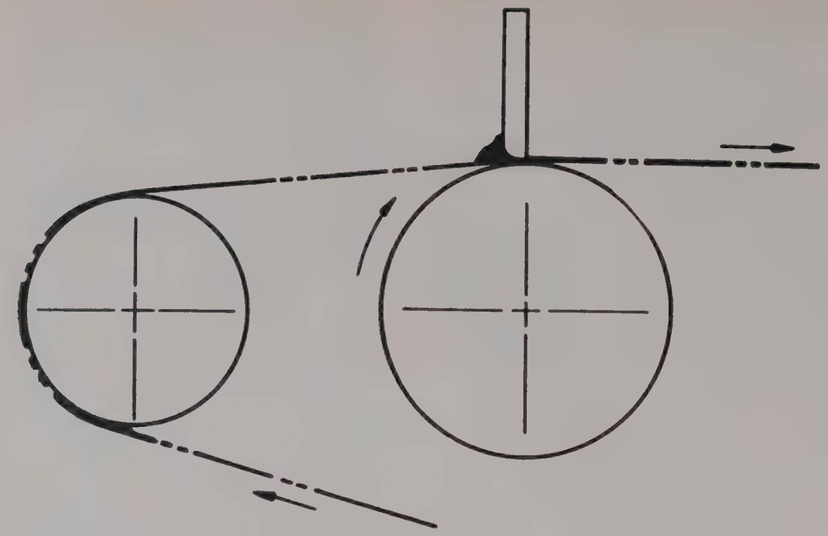
Cast coating: This is the newest and most promising coating process. The preferred design of a cast coating line has an endless stainless steel belt on which is deposited a metered amount of a coating such as plastisol or organ-



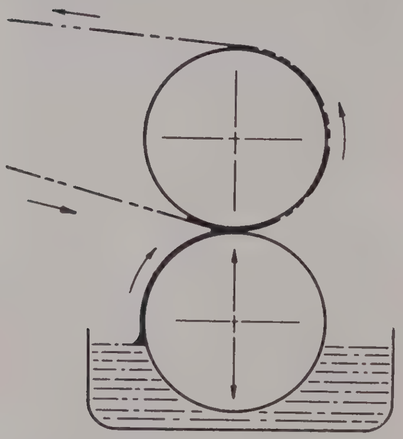
KISS-ROLL COATING

REVERSE-ROLL COATING





KNIFE-OVER-ROLL coater has knife (top) to remove excess material



SQUEEZE-ROLL coating method

osol. Application of the coating is preferably made by a reverse roll unit to insure uniformity and freedom from coating scratches. The web to be coated is applied lightly to the coated metal belt, which then travels through the fusing oven. After cooling, the web plus coating is stripped from the belt. The fusing may be accomplished by heating the underside of the belt so the web above is not overheated or scorched. This process permits any web to be used, no matter how open in construction or how "stretchy." A continuous flat coating can be obtained in thicknesses of only 2 or 3 mils.

Postmetered coatings

Knife scraper: The excess coating may be removed from a web by moving it under a coating knife of suitable edge contour. The tension of the web against the knife may be maintained by pull on the web, or it may be supported by an endless rubber blanket or roll to minimize the tension. Alternately, the web may be supported against the knife by an opposing knife edge for two-side coating.

Squeeze- or pressure-roll metering: Squeeze- or pressure-roll metering of the coating is accomplished by passing the web plus coating between opposed rolls. The rolls may be precision sized and fixed at a measured gap. Alternately, one or both of the rolls may be of resilient construction and operated by pressure against the web.

Air-blade metering: Air-blade metering of the coating on a web is the simple expedient of blowing off the excess as the web travels under a flat jet of air; control of the metering effect is accomplished by regulating the air pressure, angle of impingement, and distance of the nozzle from the web surface.

Surface treatment

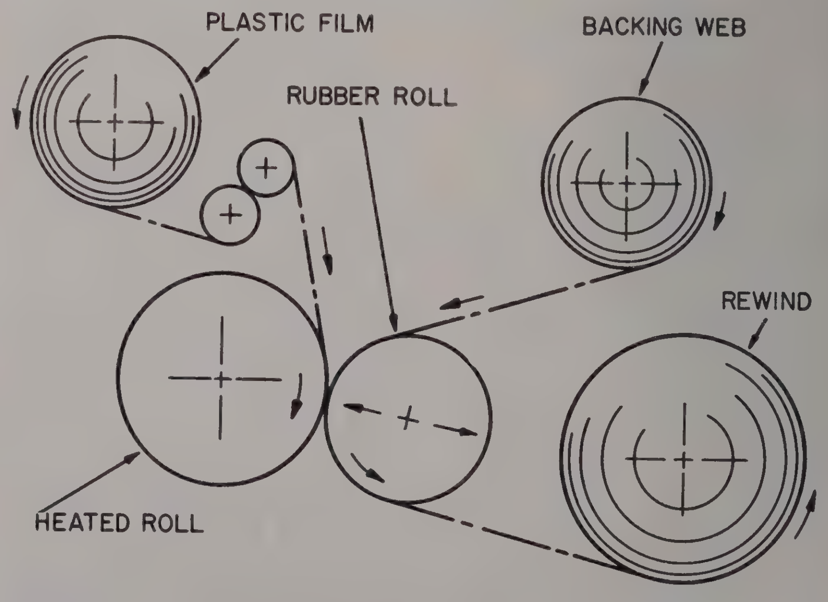
To improve the surface of a coated web before it enters the drying zone or oven, there are three principal treatments:

1) By moving the web under a flexible blade of steel, rubber, etc., the coating can be smoothed and, in the case of textiles, an improved bridging effect may be obtained.

2) The use of reciprocating brushes to improve the uniformity of coating coverage is a frequent procedure in the application of water-system coatings on board and on paper webs.

3) Spinning smoothing rolls operating against the web travel are useful to smooth relatively low-viscosity coatings.

In the ever-changing field of plastics applications, it is not possible to review all the innovations and combinations of coating techniques that are employed. The technology of handling nonwoven webs, for example, has provided suction metering of impregnated coatings. The processing of nylon tire-cord reinforcement has provided a beater-bar control of the amount of coating on a web. Materials applied or



STRETCH-LAMINATION is an extension of coating by extrusion-lamination coated on webs by static attraction provide another interesting chapter in this story. Some of the newer techniques evolved to handle hot-melt coatings in liquid and in powder form are pointing to new horizons in coating. The simple expedient of stretch-lamination (an extension of extrusion-lamination) is opening new possibilities for plastics coatings.

References

For further information on materials used in coatings, see "Resins for Coatings," p. 189; on extrusion and extrusion equipment pp. 656 and 882. Also consult the Subject Index and the Directory Index.

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EQUIPMENT FOR LAMINATING

By Robert W. Ruppert*

Laminated plastics is a catch-all phrase that covers a number of different materials—ranging from thermoplastics laminates (with decorative fillers in between) to decorative thermosetting counter-tops.

Basically, thermoset laminates consist of sheets or webs of paper, fabric, asbestos, fibrous glass, or similar materials which are first impregnated or coated with resin and then combined under heat and pressure to form commercial materials.

The sequence of operations in producing a plastic laminate involves, first, impregnating the filler or reinforcing material with the resin. This may be by means of immersion in a varnish bath, or by applying a liquid-resin solution by rollers or sprays. In the immersion method, the web or filler is fed through a tank containing resin dissolved in a solvent to form a liquid varnish. The web is then drawn out through squeeze rolls or over a doctor blade to remove excess liquid. If rolls are used to apply the resin, they are arranged to pick up the resin from the bath and transfer it to the web.

Drying after impregnation removes the solvent and partially polymerizes the resin. This leaves a fairly stiff sheet which is cut into convenient sizes for subsequent lamination. The next stage is to lay up the dried, impregnated web into a succession of plies for sheets, tubes, rods, etc., and apply pressure and elevated temperature to complete the polymerization and form the finished laminated piece.

Web impregnating equipment

Without attempting to cover all methods and machines, a general description of several systems for impregnating the web or filler will be described.

Certain sirupy resins may simply be poured over the reinforcing material on a mold. Resins of a heavier or more viscous nature are applied to the web by *knife* or *doctor blade coaters.* When the web is sufficiently strong to be pulled under slight tension, it can be run through troughs or dip tanks or through transfer rollers.

In *transfer-roll coating,* the resin is lifted as a film on a revolving roll and transferred to the web. Varying the relative speeds between the roll and web controls the amount of resin applied.

Bar-over-bar coating is sometimes used with more viscous resins on a web of high tensile strength. The web is led over a stationary bar and under another stationary bar directly above the first one. The upper bar squeezes the resin into the web fairly evenly. The gap between the bars is adjustable for control purposes.

Impregnating by immersion is another common method with more fluid resins; the web runs under an immersion roll in a tank of resin varnish and carries a heavy film of it to the nip between two other rollers where excess is removed and returned to the immersion tank. Pressure at the nip may be controlled by screws or levers forcing the rolls together, although most fillers or webs do not need extra pressure to cause penetration of the resin solution.

Spraying presents another method of applying liquid resin solutions. It is possible to closely control web resin content with this method. Also, spraying allows impregnating of webs which have resin-soluble binders. These could not be handled by the dip or roll methods, since softening of the binder would weaken the web. A simple 1-in. dia. pipe manifold with 1/16-in. holes or nozzles spaced about 1/4 in. apart has served well as a spray or drip impregnator. Several manifolds with staggered spray nozzles assure uniform coverage of the web. Pumps used to supply the liquid resin to these manifolds are usually positive-displacement types of sufficient capacity to cover the web widths encountered. The webs are moved horizontally beneath the stationary sprays and may be carried by belt or screen conveyors.

Other equipment sometimes used for impregnating webs includes: vacuum or pressure systems (when the filler is very compact and resists penetration); dusting systems which apply powdered resin over the web; and brushes for scrubbing the liquid resin into the filler.

Drying equipment

Evaporating the resin solvent and partly curing the resin after impregnation is accomplished in drying ovens. Vertical and horizontal ovens are employed with steam, electric, or gas heating. Forced-air circulation is commonly used for faster, more uniform heating of the web. Temperatures are adjusted so that the resin is only partly polymerized and the web leaves the oven in a condition permitting it to be cut and stacked or rolled without sticking together. Ovens may often be equipped with solvent recovery systems which cool the hot vapor and condense it to a liquid for re-use.

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* Consulting Engineer, Fred S. Carver, Inc., 5 Chatham Rd, Summit, N. J.

A phenolic impregnating resin is said to be in the A-stage before drying. After drying and partial polymerization, it is in the B-stage. When the impregnated material is formed into sheets, rods, or other shapes by pressure and heat, the resin reaches the cured or C-stage.

Pressure-applying equipment

Final polymerization is usually carried out in a press where the laminate is formed to some desired shape or is simply press polished. Forming operations usually call for slow-moving machinery capable of applying pressure gradually and holding at the desired maximum pressure until complete curing has taken place. It would be impossible to describe all the numerous presses available for laminating work since almost any device which will apply pressure could conceivably be used, and practically all conventional types of presses have been used in laminating sheet plastics.

Large presses

For large-size work, it is necessary to use hydraulic presses capable of exerting forces of hundreds of tons. These presses generally contain many platens so that several stacks of plies can be processed at one time. The laminates are not placed directly between platens but rather are held between highly polished plates which in turn are placed between the platens. Polished plates produce a smooth, glass-like surface on the finished product. Of course, these plates may also have other finishes such as sand-blasted, etched, etc.

The larger presses are most often automatic or semi-automatic and have self-contained hydraulic pumping systems to provide both high- and low-pressure operation. Frequently, accumulator-type systems are used.

Many large, multiple-platen presses for laminating and polishing plastic sheets are provided with a loading and unloading elevator which facilitates handling large sheets. The elevator may be hydraulically operated from the press pumping unit or powered separately by other means.

The use of vacuum is commonly encountered in low-pressure laminating where atmospheric pressure is sufficient and the parts being formed are large and of irregular shape. In this method, air is withdrawn from the space between a solid mold and a flexible membrane with the laminate in between. Atmospheric pressure forces the membrane and the laminate against the mold. Equipment required usually consists of conventional vacuum pumps of the radial or vane type connected through a large tank to prevent fluctuations in vacuum supply. As a general rule-of-thumb, minimum tank capacity should be approximately 1½ times the volume of the largest forming chamber used.

Vacuum gages are mandatory for determining and controlling the force exerted on the laminate. Also required are good connections between the vacuum tank and the mold. Flexible tubing allows more freedom of movement and is a convenient method of making these connections. Control valves are needed in the line from the vacuum tank to the mold for controlling the applied vacuum and for releasing it by admission of air.

Fluid pressures above atmospheric are also used in forming laminates. One part of the mold is rigid, the other is a flexible membrane. Steam, air, inert gases, water, oil, or combinations of these are used under pressure against the diaphragm. For gases, two-stage compressors having auxiliary receiving tanks of sufficient volume are used, the receiving tank again acting to reduce pulsations of pressure. For liquids, positive displacement pumps are usually recommended. Again, pressure gages, control valves, etc. are required for proper regulation. The forming chamber is designed to withstand the higher stresses induced and is heavier than that used in vacuum work.

Autoclaves are used frequently in laminating plastics. In this method the mold and flexible membrane are placed inside the pressure chamber and pressure is applied to both at the elevated temperatures within the chamber.

Heating equipment

To form the desired shape and complete the curing, the laminate must be heated. Heating methods vary according to the type of plastics being treated and the type of forming equipment used.

Hot press platens are commonly used for heating sheet laminates. Platens are usually cored or channelled for steam or hot water circulation which allows fast heating with good control. Often the platens are made of aluminum for better heat transfer. Temperatures usually range from 270 to 350° F. Small high-pressure boilers can handle the average press, providing uniform controlled heat, usually within 5° F. of set temperatures. Boiler capacities naturally depend on the size and number of platens or molds to be heated. One approximation is 2 hp. per press, but this may be high on small presses. Hot-water and oil heating systems are also used.

Where a quick change is to be made from heating to cooling the same platens, as in laminating cold-set plastics such as cellulose acetate, vinyl, etc., a multiple steam-water valve is used to cut steam supply and admit cooling water to the platen or mold. The design is such that a quick change can be made by operating a single handle. On resetting to heat, the steam purges any remaining cooling water and quickly begins reheating the platen.

Electric cartridge, strip, and open coil heaters of various types may be used to heat both platens and molds. Heater elements are cast into the platens or are inserted into holes carefully machined to assure good contact and heat transfer. Various wattages are available and it is common to use higher platen temperatures to compensate for the temperature drop when work is placed between platens.

Electric strip heaters are useful on irregularly shaped molds, etc., and are obtainable in varied widths up to about 6 inches. Operating temperatures from 750 to 1500° F. and higher are common. Rheostat or thermoswitch controls may be used to adjust and maintain desired temperatures in a similar fashion as with cartridge heaters.

Open-coil heaters are sometimes used to soften thermoplastics for forming and there is at least one plastics laminating machine on the market which uses open-coil heater radiation directed to a platen of low thermal mass and high radiation absorption. Platen temperatures of 300 to 400° F. are reached in a matter of seconds. Suitable insulation and radiation protection for parts not to be heated must be provided with this method.

Dielectric heating is sometimes employed on plastics that can absorb energy from a rapidly alternating electromagnetic field. This method offers extremely fast, uniform heating since heat transfer does not depend on conduction. Heat is developed within the dielectric (plastic) by molecular action. Initial cost of such equipment is relatively high, but for certain production applications its speed, cleanliness, and convenience make it highly desirable.

Infra-red heaters or lamps similar to those used in paint baking and drying ovens can be used to heat plastics sheets prior to and during laminating.

Cooling equipment

Most of the obvious and more common methods of cooling, in general, are applied to plastics laminating machinery. Already mentioned is the use of cooling water circulated through the cores of platens. Ordinary city water or other liquid coolants may be used. To save time, some laminating presses have separate cooling platens to which the laminations are transferred after heating. Pressure is reapplied and maintained during the cooling phase. The cores of the cooling platens are sometimes made the evaporator of a small refrigerating system so that fast chilling of the laminates is obtained by the greater temperature differential so produced. Refrigerated liquid from a separate low-temperature supply tank can be pumped through the cored platen also.

Forced-air cooling is employed on many small laminating presses by means of self-contained blowers. Air-cooling is naturally slower than with other methods but eliminates considerable extra equipment and allows smaller presses to be completely portable.

Molds and polished plates

Molds for plastic laminating are varied and many but are distinguished by their intended use, i.e., whether they are to be used for high-pressure or low-pressure laminating. A great difference in mold materials depends on this distinction. High-pressure laminating molds are not unlike those employed in compression molding of plastics. They are usually of steel construction, although other metals may be used, and are relatively small in size compared to those used in low-pressure laminating. They are considerably more expensive and thus are more economically used for items of large-scale production.

Low-pressure laminating molds, however, lend themselves nicely to small production, irregular shapes, and fairly large parts such as boat hulls, aircraft wing sections, etc. One of the most inexpensive materials used is plaster of paris. Hydromite, a special plaster of paris, contains a resin and sets to a very hard, smooth surface. Large plaster of paris molds have been successfully used for laminating boat hulls and other similar shapes. Wooden molds are common in low-pressure laminating work. In the bag method, wood molds may be quite light and need not be excessively braced. Sheet and cast metal molds are often used for the larger laminates. Other mold materials which have been used in low-pressure laminating are concrete, thermosetting plastics, low-melting-point alloys, etc.

The finish on the mold surface is reproduced on the laminate. Polishing and plating are therefore often used to secure extremely smooth surfaces with combined good release characteristics. Chromium-plating is common for this application.

In the press polishing of plastics sheet materials, the plates may be made of steel, stainless steel, aluminum, copper, brass, etc. and are usually highly polished and then chromium-plated for high luster and surface protection. Hard-chrome plating is used for better wear and scratch resistance.

Thermoplastic laminating

One of the big applications for thermoplastic sheet laminates is in the preservation of documents, papers, etc.[1]

Laminating equipment used by document restorers commonly comprises flatbed, steam-heated, hydraulic presses or roller-type presses with electrically heated preheating sections or platens preceding the rollers which apply pressure as the work passes through. So long as proper attention is given to the operating variables of time, temperature, and pressure, good laminations can be produced by most any type press. The roller-type press has the advantage of being continuous, with prepared work being fed in one end and finished work emerging from the other.

Air ovens are frequently required for removing moisture from paper and photographs prior to lamination. Excessive moisture in paper will cause bubbles and other undesirable effects on the finished laminate due to steam formation during the heating cycle.

It has been found that acids may accelerate degradation of the paper and the plastic during lamination. Neutralization is accomplished by immersion of the paper in a tank containing a mild alkaline solution, followed by oven or drum drying.

Special cements are used to increase the adhesion of plastic to the glossy surface of photographs when being laminated. Compatible cements are available for the particular type of plastics used such as the acetates, vinyls, etc. In many cases, a good photograph lamination cannot be made without the use of such cements.

Small, portable, rigid laminating machines for office use are complete package laminating units, combining press, heating and cooling means, and automatic cycling with shut-off when lamination is completed. Identification cards, credit cards, etc. can be made up, laminated, and trimmed in a matter of minutes. Many such cards are embossed for service as credit cards and may be used to imprint sales papers, etc. This type is gaining favor over metal plates.

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[1] "Preserving documents by lamination," Technical News Bulletin of the National Bureau of Standards *42*, 54 (March 1958).

Various cutting and trimming equipment is used by laminators but is not of any specialized nature.

EQUIPMENT FOR CALENDERING

By Kendrick J. Gooch*

In calendering plastics film and sheeting, the degree of quality and economy obtained depends largely on the amount of careful planning entering into the design of the complete calender train. Material should flow from resin storage through the processing operations to packaged rolls of finished goods with a minimum of human effort. The size of related train components, e.g., mixers and mills, conveyors, calendering rolls, etc., should be in proportion both to production requirements and to each other, so that they will be used at their maximum rate of output.

Primarily, the process of calendering is used to form plastics material into a continuous sheet with controlled thickness and surface finish. This operation is performed between two or more pairs of rotating beams called rolls. Each roll pair constitutes a rotating die through which the material is either drawn or extruded, or both.

Mixing the resin

The initial step in the calendering operation is the mixing of the resin. Various types of intensive mixers and mills are available that can be arranged to suit specific production requirements.

The tower-type of preblending arrangement, for example, is one that requires a minimum of material handling. Resin is blown through piping, or elevated in bags to high storage bins. It drops from the bins onto shaking screens, flows by gravity through sifters and into traveling weigh hoppers which feed the blenders, and from the blenders pours into weigh-hoppers located directly above a Banbury mixer hopper door.

If both film and sheeting are to be produced with the same calender train, good results can be obtained by using a setup such as is shown in Fig. 1, p. 949. In this arrangement, two 3A Banburys are installed with the hoppers facing each other. One operator can thus control both units for producing thick-gage sheeting, and a single unit can be used at maximum capacity for the thin-gage films.

For producing a wide range of finished gages, two mills should be used. One of these mills should be mounted directly under a Banbury. The second should be opposite the first, so that the adjusting screws are on adjacent sides and one operator can control both mills. Material is carried by strip-feed conveyor (a narrow, flat-belt, hugger-type unit) from the first mill to the second, and then to the calender feed bank. The calender can also be supplied directly from the first mill.

Metal detection

In setting up calendering equipment, it is important that provisions be made to keep metal-contaminated material from being fed into the calender where it would mark up the calender rolls.

When using the strip-feed conveyors described above, small-gap, sensitive metal detectors should be installed. Strip-feed conveyors can also be designed to cut out and automatically discard a length of material containing a metal particle, with a minimum of lost feed to the calender. This is essential for high-speed calendering.

A more positive means of metal elimination is obtained by using an extruder with a strainer-type head. This method is relatively expensive, since a large unit having an adjustable-speed drive, synchronized with the calender speed, is required. However, the strainer removes all solid particles, not just metallic objects. This added protection more than offsets the higher initial cost when surface finish is important.

Calendering rolls

The latest trend in plastics calendering is toward calenders designed for higher roll temperatures, greater roll separating forces, and a wider range of available friction ratios.

Several types of roll arrangements are available for selection, based on ease in threading, accessibility of the rolls, and general convenience for a particular operation. The "Z" and the inverted-"L" arrangements are standard in the industry. A recent development is the inclined "Z" which provides a clear and short path for material travel, permits easy accessibility for coating fabrics, and enables the embosser or other attachment to be placed close to the pickoff roll. The calender shown in Fig. 1 has the feature of crossed-axes on the No. 4 roll together with the advantage of taking the material from the No. 3 roll instead of the No. 4 roll.

Few plastics calenders are designed to make only a single size of sheeting from a single stock. Usually, maximum flexibility is desired so that thin films and heavy sheeting can be produced to satisfy changing market requirements. This, in turn, means the rolls will be subjected to a wide range of separating forces. These forces bend the rolls, changing the shape of the aperture between them. If some compensation for this bending were not made, the sheet thickness would vary considerably over its width. To keep the sheet flat, two techniques of compensation are used. In one—roll-bending—an opposing bending moment is applied to the rolls. In the other—

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* Assistant Div. Engineer, Mill and Calender Div., Farrel-Birmingham Co., Inc., Ansonia, Conn.

References were prepared by the editors.

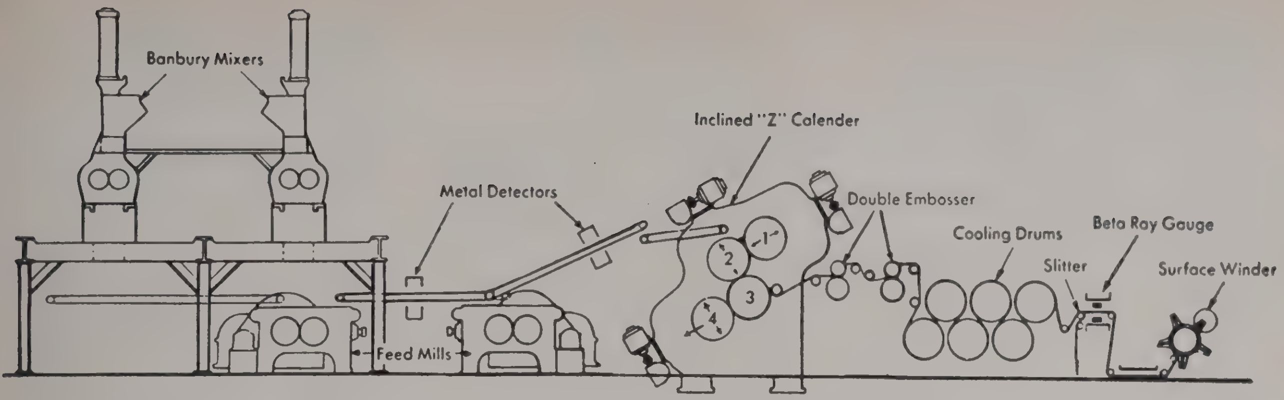

FIG. 1: Calendering setup for making both film and sheeting with same calender train

roll-crossing—one roll axis is crossed slightly with respect to the other by causing it to pivot about its midpoint of length. Both roll-crossing and roll-bending devices are now available for installation on existing calenders.

Several calenders recently built are equipped with individual motor drive for each roll. This is accomplished either by connecting each roll directly to a gearmotor through a universal spindle, or by using a semi-uni-drive between the gear motors and the spindles. Both of these arrangements provide a wide range of roll friction ratios, which are advantageous for the newer types of plastics compounds. Since these compounds require high power at slow speeds, calenders should be driven by motors having a low base speed. Such motors have been designed for calendering rates up to 100 yd./minute.

Material coming from the calender should have a reverse wrap around closely spaced carrier rolls to prevent pull-down in width. Free-turning rolls with spindles driven to eliminate friction are required near the calender.

The recent trend in post-calender embossers is toward double or turret-type units in order to provide a quick change of pattern. The type of embosser required depends on the embossing pressure and whether or not the rubber roll, as well as the embossing roll, must be frequently changed. High-pressure embossing at top calender speeds requires a heavy-duty driving motor.

Cooling rolls are usually driven in groups of three for best speed control. The number required depends on the heat to be removed, and this is proportional to the sheet thickness and production rate. Slow-speed film calenders may have only three cooling rolls; high-speed sheeting calenders will have nine or more.

Many calenders now have two-speed, motorized roll adjustment with the low speed designed for use with automatic gaging. Beta-ray gaging equipment has now been designed to control not only the longitudinal and edge gage, but also the entire profile. In automatic profile control, the beta-ray gage governs the roll-crossing or roll-bending equipment.

The type of winder is usually determined by the gage of material of primary interest. Film tensions are readily controlled on a surface-type winder. Large rolls of sheeting may be better handled on a two-arm center winder. For both types, the material should be cut off and started on the new roll as automatically as possible. Winders for coated fabric must have special cutters in order to cut through both plastics and fabric without reducing the calender speed.

Drilled rolls and circulating liquid temperature control are an accepted part of almost all plastics calender installations. Now, mills, and in some instances Banbury mixers, are also being controlled in temperature by similar systems.

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EQUIPMENT FOR HEAT-SEALING

By M. S. Abraham*

Standard heat-sealing machines consist basically of two parts: a high frequency generator and a sealing press. The generator is like a radio transmitter in that it converts the standard 60 cycle current into high frequency.

The generators are manufactured in various sizes, starting with a power output of ½ kw., up to 100 kw. The most common sizes in use are 3, 5, 8, and 10 kw. The size of the generator is determined by two factors: the sealing area and thickness of material. Table I, p. 950, shows the necessary power for a 1/16 in. wide seal in different thicknesses of materials.

The actual working part on a heat-sealing machine is the press. Presses are also made in different sizes, depending on individual requirements. The press has to be sturdily built with a wide ram and adjustable gibs. The part of the press where the die is to be mounted is called a platen and has to be absolutely level with the working bed. It is sometimes

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* Gen mgr., Cosmos Electronic Machine Corp., 656 Broadway, New York 12, N. Y.

TABLE I: Sealing power required for 1/16 in. wide seal[1]

Generator output	*2 layers of vinyl 0.004 in. thick*	*2 layers of vinyl 0.010 in. thick*	*2 layers of vinyl 0.020 in. thick*
kw.	*in.*	*in.*	*in.*
3	50	85	110
5	80	135	160
8	125	245	290
10	150	250	330

[1] These figures may vary with quality of the film and physical size of the die.

necessary to readjust this level. A good press should be so constructed that it has level adjustments on the platen and on the working bed. Presses are operated by compressed air. This has proved to be more practical and economical than hydraulic or motor drives.

Accessory equipment

Almost every heat-sealing machine manufactured today is equipped with an arc eliminator. The arc eliminator prevents damage to the die in case arcing occurs. This arcing is sometimes unavoidable due to air space between the die and the plastics (press not level) or to foreign particles which sometimes settle on the plastic material.

Another important factor is safety. The heat sealer should have a safety device which makes it impossible for the operator to get his hand between the electrodes during operation.

Some heat-sealing machines are equipped with a radiant heater[1] which is located between the platen and the heat-sealing die. By heating the die to a certain temperature, additional sealing power can be created in many instances and arcs and sparks may be minimized. The radiant heater is a necessity for making appliqués.

The heat-sealing dies or electrodes are shaped to the exact form of the item to be sealed. These dies are made of brass rules. In common use are the tear-seal dies, which consist of a sealing and cutting edge. This cutting edge precuts, in the same heat-sealing operation, the finished seal. The overflow is torn off very easily, leaving a finished edge. In many cases, the sealing edge of the die is engraved in various designs which reproduces the same pattern on the edge of the plastic item.

There are many firms that specialize in the manufacturing of heat-sealing dies. A kit now on the market contains all necessary tools for making heat-sealing dies.

Operating techniques

Basically, all virgin vinyl film, no matter how thick, can be heat-sealed. In recent years, plastics films have appeared on the market incorporating a percentage of reprocessed vinyl. Some of these films can be sealed with excellent results while with others some difficulties arise. For this reason, it is advisable to make sealing tests before going into production with any material made of reprocessed vinyl.

The actual operation of a heat-sealing machine is very simple. A loading tray which should exactly match the outline of the sealing die is mounted on the working bed of the press. The plastic to be sealed is placed into the loading tray. The operator pushes two buttons simultaneously, which starts the following automatic sealing cycle:

The ram with the attached die comes down, the power goes on, the power stays on for the necessary sealing time, the power goes off, the ram goes up. This cycle usually takes between 2 to 4 seconds.

The loading usually takes much more time than the sealing operation. For this reason, it is advisable to work with removable trays than can be preloaded and handed to the sealing machine operator so that the sealing machine is not idle during the loading time.

Other methods of speeding up production are the use of turntable and roller-feed machines.

In the first method, loading trays are mounted on a turntable, the number depending on the size of the items to be heat-sealed and the size of the turntable. For example, on a 60-in. dia. turntable, either four trays for ring-binders measuring 8½ by 11 in. or twelve smaller trays for wallets can be mounted.

The turntable sealer works as follows. First, the trays are loaded. Then, each tray moves automatically underneath the die. After the seal is completed, the next tray (or station) moves into the sealing position.

The turntable should be adjustable for 2 to 24 stations and can mean tremendous savings for large production runs. For small runs, the cost for additional trays may sometimes be prohibitive. For this reason, the machine should be so constructed that the turntable can easily be detached from the press and the heat-sealer used as a standard machine.

The roller-feed machine can usually give the fastest production rates possible. This machine can only be used economically for simple items where two or three layers of vinyl are to be sealed, e.g., belts.

With a roller-feed machine, two or three rolls of plastics material cut to exact width are mounted on the side of the heat-sealer and are pulled across the bed of the press between guides by rubber rolls. This movement stops and starts again automatically for each seal.

A recent development in the heat-sealing field is the making of different colored edges of three-dimensional appliqués in multiple colors.[1] For this operation the above mentioned radiant heater is necessary. The press has to be precisely built, 100% level, and must contain a precise, split-second timer.

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[1] Patent of Cosmos Electronic Machine Co.

EQUIPMENT FOR ROTATIONAL MOLDING

By T. A. Miller*

Both resilient and rigid hollow objects can be produced from vinyl plastisols by rotational molding. An extension of slush molding, the rotational process makes it possible to produce objects in which uniformity of wall sections, surface quality and detail, and part weight can be more accurately controlled. At the same time, labor costs, floor space required, and number of rejects can be significantly reduced and output can be substantially increased.

General procedures for both slush and rotational molding are discussed in the article starting on page 740. Rotational molding is, of course, limited to completely enclosed articles or to those from which sections are subsequently removed. Otherwise, there are practically no limits to the variety of shapes which can be produced.

Rotational molding equipment consists essentially of one or more spindles on a rotating table, radial supporting arms with spiders on which the molds are mounted, independent electric motor drives by which mold rotation is controlled, an enclosed oven and water-spray cooling area through which the spindles pass, and a station where the operator removes the molded pieces and recharges the molds.

Size of equipment is determined by the projected volume of output. One six-spindle machine, for example, has a capacity of 1620 molded pieces per hour. Cycle time can be varied from 12 to 20 min.; rotational speeds of both the spindles and the radial supporting arms can be controlled to meet the needs of the parts being molded.

At the beginning of the cycle, the molds are charged with an automatic dispensing gun which controls the amount of plastisol injected into the mold. This makes it possible to predetermine exactly the weight, and consequently the wall thickness, of the part. The top section of the hinged spider, which contains the upper sections of the molds, is then closed and tightened with a power wrench. These steps are accomplished while the table is in motion.

As the rotating table carries the spindle to the oven, a Microswitch starts the spindle rotating; a second switch stops it as it emerges from the cooling area.

Temperature of the oven is maintained automatically within the range of 460 to 540° F. Heating is either by gas or electricity.

After cooling, the molds are opened and stripped by hand. Aluminum and copper have proved to be the best metals for making molds for rotational molding. Both are easy to work and can be quickly heated and cooled. Direct machining of aluminum stock is the least expensive method of making molds, where the number desired is not too great and the object to be molded is not too complex. Pressure cast aluminum cavities are generally used when a great number of molds is required and where the die cost can be justified by the length of the run.

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*Pres., The Akron Presform Mold Co., 2038 Main St., Cuyahoga Falls, Ohio.

EQUIPMENT FOR MOLD MAKING

By L. J. Morrison* and Frank S. Marra*

In recent years there have been some definite trends in the making of injection molds for plastics that have directly affected the equipment required for mold making. A few of the more significant trends are:

1) The increased use of prehardened steels.

2) The advent of new processes for producing cavities and the wider use of various processes other than conventional machining.

3) The widespread acceptance and use of standard mold base assemblies and mold plates in a semi-finished or finished ground condition.

4) The trend away from the "knee-and-column" type of milling machine in favor of the more sturdy, "solid base" type of machine.

Since each of these trends and processes still have their own specific limitations, the need for many of the conventional types of equipment used in the past still remains.

Types of equipment used in producing mold cavities will be outlined in this article.

Some processes, such as "hobbing," can be and are being done by the mold-maker in his own shop; however, much of it is being done by companies specializing in these services. Other processes, such as the Shaw Process, are still restricted to the more qualified sources.

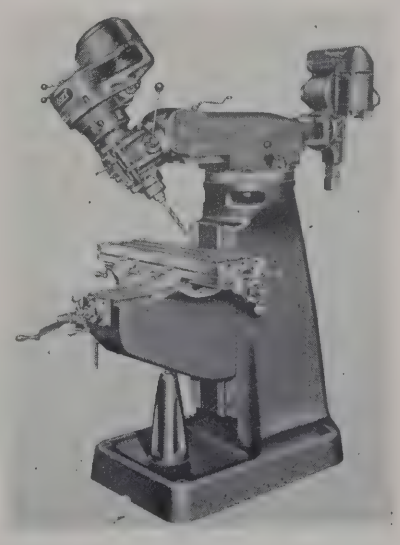
Basic equipment

The *power hack-saw* is the most commonly used machine for rough "sizing" bar stock before machining. This type of saw uses a heavy, high-speed steel blade and can cut tough, alloy steels.

Band saws are important for rough stock removal when contours or through pockets are required.

The abrasive *cut-off machine* is useful for cutting small quantities of rods or bars with accuracy and high speed. This type of machine

VERTICAL milling machine: "knee-and-column" design with swivel head



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* Detroit Mold Engineering Co., 6686 E. McNichols Rd., Detroit 12, Mich.
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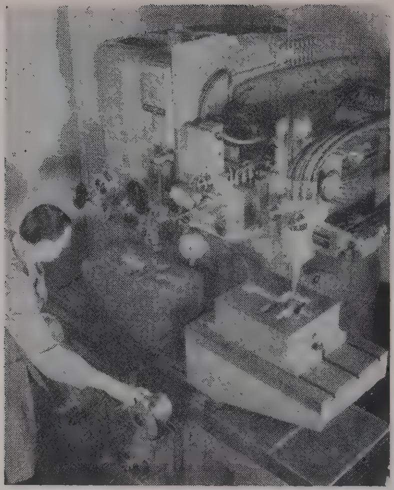
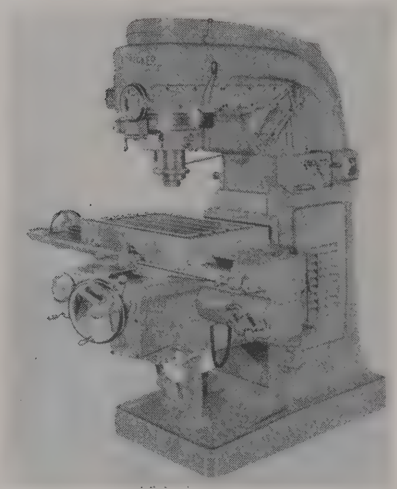


VERTICAL milling machine: "bed" type with power feed duplicator. (Cincinnati Milling)



ROTARY HEAD vertical mill of the two dimensional type. (Photo, Kearney & Trecker)

uses a rubber-bonded abrasive wheel at extremely high speeds.

Acetylene torches are often used for rough-cutting soft machine steel and are especially useful for cutting irregular shapes.

The *shaper* and *planer* are used for forming plane surfaces, such as in squaring-up mold plates and for heavy stock removal on cavity blocks.

The single-spindle *vertical drill press* is the most common piece of equipment required for drilling holes in mold plates or component parts. They range from small, very sensitive models to units that will drill 3-in. diameter holes and larger.

The *radial drill press* is especially useful for large work, since it is unnecessary to move the heavy block in order to drill several holes in the same surface of the piece. It is also used for roughing out large circular cutouts and for drilling water or steam lines. *Horizontal drill presses* are also useful for drilling extra-long water or steam lines.

The *lathe* most commonly used in mold-making is the engine lathe, with special attachments that classify it as a "toolmakers' lathe." It is used widely in mold shops and is indispensable for forming pieces having circular cross-sections. Some of the attachments available for lathes are internal and external grinders, milling attachments, special holders, and chucks.

Grinding machines: There are many types of grinders designed for various purposes.

Vertical rotary surface grinders, rugged and rigid, are used principally for preparing flat stock for subsequent fabricating operations.

Reciprocating surface grinders, also used for flat stock, hold the work magnetically to the table while it is made smooth and parallel after shaping and hardening.

Jig grinders eliminate makeshift methods of correcting holes after hardening. They do away with dowel gages and end blocks, because the hole location is obtained through accurate, hardened guide screws, and thus makes any additional corrections unnecessary.

Cutter grinders: In precision milling, duplicating, or engraving work, cutters must be reground as often as 20 times per day to ensure accuracy. Cutter grinders, designed for such sharpening operations, are provided with graduated dials and adjustments.

A pedestal or bench grinder, consisting principally of a motor with a grinding wheel mounted on each end of its shaft, is required equipment for sharpening small tools.

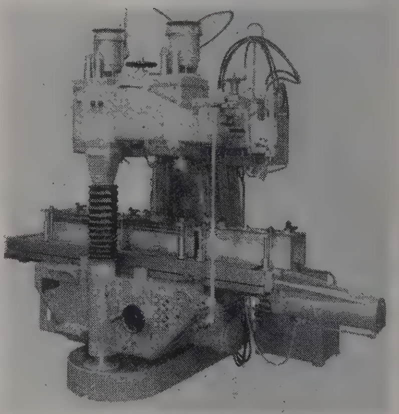
Finishing

Preparatory and finishing operations on molds are accomplished with a variety of auxiliary bench equipment. Two of the most commonly used items in mold shops are *filing machines* and electric or air-operated *hand grinders.* The hand grinders use both abrasive "mounted wheels" and carbide cutters. The hand finishing operations are done with "riffle" files, abrasive sticks, lapping sticks, bristle brushes, and felt bobs. These hand-polishing operations are used with abrasive powders, lapping compound, and diamond compound on hardened cavities to bring them to a high luster.

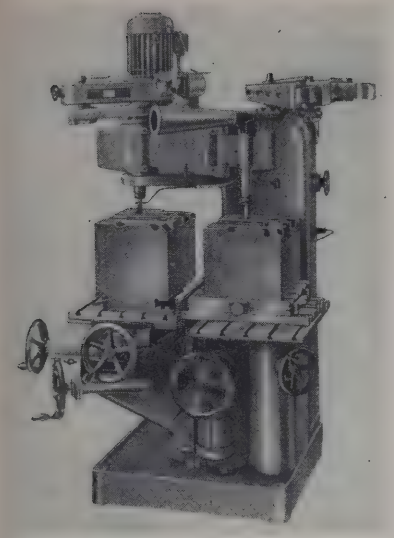
Milling machines

The piece of equipment that is most characteristic of a plastic mold making shop is the milling machine. The type most commonly used, and often referred to as the "workhorse," is the *vertical milling machine.* There are two basic types of vertical mills: the "knee-and-column" type and the "bed-type." Each of these two basic types have their advantages.

SINGLE SPINDLE duplicator with horizontal spindles. (Photo, Pratt & Whitney Co.)



AUTOMATIC duplicator with multiple spindles and "reverse image" feature. (Cosa Corp.)



PANTOGRAPH of three-dimensional type (Photo Cosa Corp.)

The relatively lighter machines are usually of the "knee-and-column" design. This type offers the facility of being able to raise and lower the table. This feature enables a wider range of work piece height to be used without over-extending the spindle.

The "bed-type" has gained popularity in recent years due to its rigidity. This rigidity in the table of the machine has become more important due to the increased use of prehardened steels and the added forces required to machine them effectively.

Vertical milling

In its simplest form, the vertical milling machine has a hand feed on the transverse, longitudinal, and vertical table movements as well as on the spindle movement. The larger and more powerful equipment invariably have power feeds on all table movements. The more modern types of milling equipment are becoming increasingly important to the mold shop. The later models of milling equipment are not only built sturdier and with greater precision, but they will do more complex jobs with greater ease and in less time than many of the older mills still in use today. Accessories are available on some vertical mills that enable the spindle to be set in a variety of planes and also include slotting attachments.

The rotary-head-type vertical mill readily machines any profile

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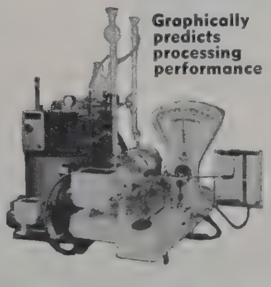

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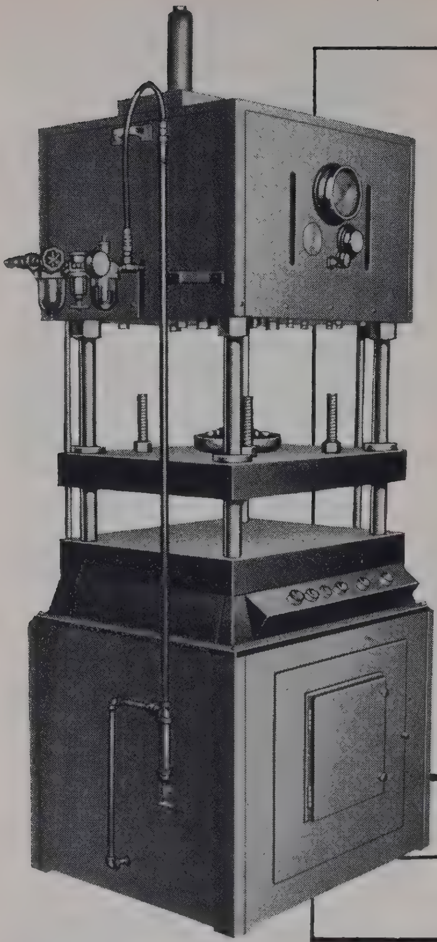

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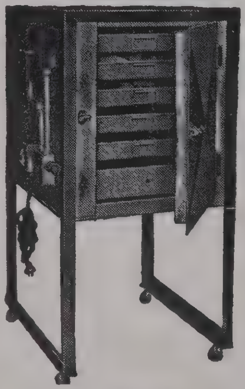

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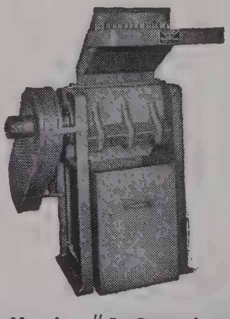

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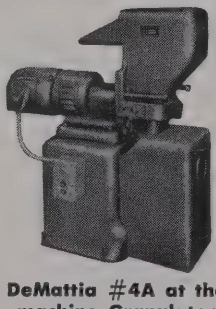

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that can be drawn with a combination of straight edge, compass, and protractor, with power feed on the table and spindle movements.

Duplicators

For duplicating from a master of the proposed cavity, there is a variety of special equipment that can be attached to standard milling machines. These attachments are quite satisfactory but they usually require hand feed on the table and spindle movements. Machines designed expressly for duplicating and having power feeds are also available. These machines are available with multiple spindles as well as single spindle arrangements. In machines incorporating the use of a horizontal spindle, chips fall clear of the cutter as the work progresses.

Duplicators that have a "reverse image" attachment, i.e., will cut either a right- or left-hand cavity from the same master, are available. They can also cut as many as four cavities simultaneously from one master.

Pantographs are a modified form of milling machine in which the tracer is guided manually over a template, in the case of a two-dimensional machine, or over a master in the case of the three-dimensional types. The tracer is "linked" to the spindle by a pantographic linkage that enables the movement of the tracer to be accurately duplicated by cutter. These machines can be set so that an enlarged master or model can be used with the tracer and a proportional reduction in cutter travel is obtained. This feature enables small details to be more truly reproduced in an enlarged template, thereby imparting closer adherence to detail in the finished cavity.

Jig borers

A jig borer is actually a combination drill press and vertical milling machine. It allows locating and spacing of holes with extreme accuracy, and is used for laying out the cavities of the mold.

Hobbing

Hobbing is one of the best methods for insuring uniformity and economy in production of multiple-cavity molds and should be of great interest to all molders and mold-makers. Hobbing presses have increased in capacity from approximately 50 to 3000 tons and even more. A hobbing press is basically a hydraulic press that is more sturdily built than ordinary presses because it has to deliver more concentrated force. Between its two platens is placed the mold blank, on top of which is placed the hob. To support the soft mold blank, and keep it from spreading diametrically away from the hob while being formed, a hardened chase or hobbing ring is used. The ring is not necessarily round; it may be rectangular in shape.

On one-push impressions, the amount and location of relief is important, but it is on those impressions requiring two or more squeezes that the hobber's skill and experience, and the suitability of the hobbing press, really come into play. It takes only a few misguided seconds in a hydraulic press to ruin a hob on which many hours and many dollars have been spent. When hobbing is being considered it is wise to consult a good hobber before making either hobs or blanks.

A modification of the hobbing process is used to pressure-cast high-fidelity cavities from beryllium-copper alloy. This alloy is not as rigid or as hard as steel, but is easier to work and has much higher thermal conductivity. Like steel hobbing, beryllium-copper pressure casting is a specialized process that benefits from experience.

Shaw process

The Shaw process is a patented process, available from licensed firms having a licensing arrangement. This process involves precision-casting of all castable metals, including steel, into cavities and cores, hobs, and inserts. By so doing, costly machining or engraving operations are avoided.

Castings up to 10 lb. have been most typical of production on present equipment, but larger ones have been made. Wall sections as thin as 1/16 in. can be readily provided in steel castings made by this process.

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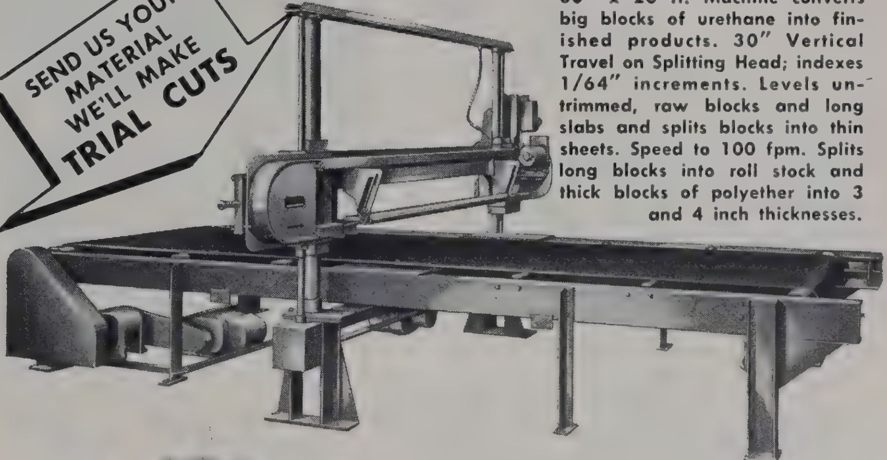

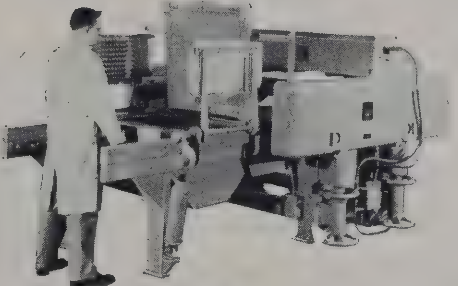

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are usually provided in the annealed condition (Rockwell C 15/20). After subsequent machining for ejector pin holes, etc., the usual procedure is to harden and polish the cavity to the specified requirements.

Electroformed cavities

In one respect, electroforming resembles casting or hobbing, in that the metal is formed against another part. In electroforming, however, this "master" is not subject to stress or heat. The electroforming operation takes place in a chemical bath at a temperature that is barely warm to the touch.

The most preferred plastics materials for making the master are the methacrylates and the acetates; however, other materials, including cast phenolics, nylon, styrene, molded phenolics, and ureas, can be used. Of the metals adaptable for masters, brass is preferred.

The actual process for producing electroformed cavities is as follows: The master is placed in a chemical bath and connected to an electric circuit. The plating metal, which is hard nickel, is dissolved in the fluid. When the electric current is passed through such a fluid, the dissolved metal is attracted to the cathode, or master. There it is deposited, molecule by molecule, covering every detail of the master. When this layer becomes about 5/32 in. thick, the original cathode is removed and we have the electroformed part remaining.

This layer of hard nickel has a hardness of 45 to 50 Rockwell C and has excellent elongation and tensile qualities. For reasons of time and economy, a sufficient mass of copper, with a hardness of 220 Brinell, is electroformed on top of the nickel layer. The thickness is such that the resultant mass can be machined to any geometric shape for insertion into the mold.

The use of electroformed cavities have found beneficial applications for deep narrow cavities, cavities with intricate detail or varied surface patterns, curved parting lines, and undercut sections.

This process has also found acceptance in the field of slush casting molds due to the high throwing power of the copper bath. This feature enables doll body molds to be actually thicker in the armpits and crotch than they are elsewhere.

Electrical discharge machining

This process uses a "master electrode," which is a male copy of the cavity, to electrically "machine" the steel cavity into the mold. The electrical discharge machining process itself is relatively fast and automatic; however, prior to electrical machining, the electrode master must be manufactured. Briefly, the electrode is manufactured as follows:

The electrode material is first heated in a lead melting pot to a temperature of approximately 750° F. It is then ladled into a master steel cavity, which has been previously heated to 350° F. by a thermostatically-controlled electric hot plate. The master steel cavity is set on a 75 ton press in a retaining enclosure and the molten electrode material is poured into the master cavity. A sustained pressure of approximately 500 p.s.i. is applied until the metal has solidified. Shrinkage is about 0.001 in./inch.

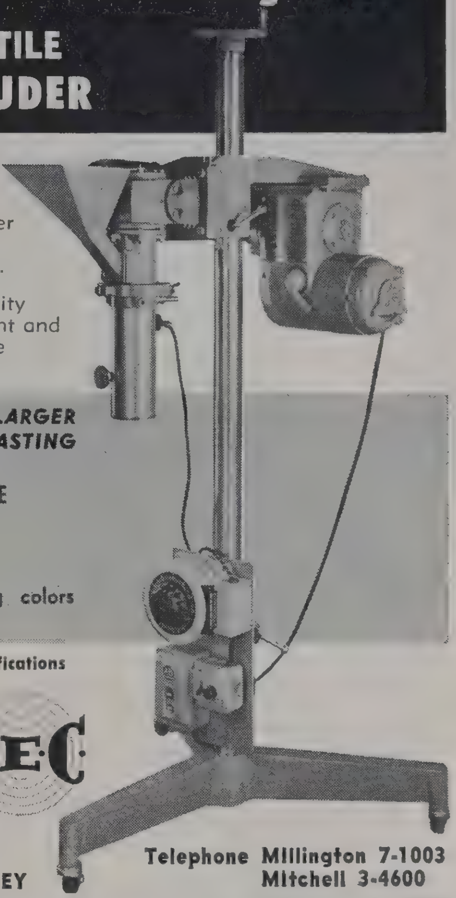
The electrode is then machined for mounting into the electrical discharge machine. Prior to mounting it is rough etched about 0.015-in. undersize and chrome-plated to within 0.005-in. of size with hard chrome. It is then finish etched to about 0.006-in. undersize and rechromed with an additional 0.004 in. of hard chrome.

After the electrode is completed, any number of cavities can be reproduced from it in the electrical discharge machine. From this point on, the electrical machining process is automatic; that is, the machine will run to a specified depth and shut off.

The electrodes can be used repeatedly and can be rechromed if necessary.

Chromium plating

Chromium plating gives the plastics industry the advantages of harder surface, less sticking, elimination of pitting caused by gases of reaction, reduction in breaking-in time, high finish of



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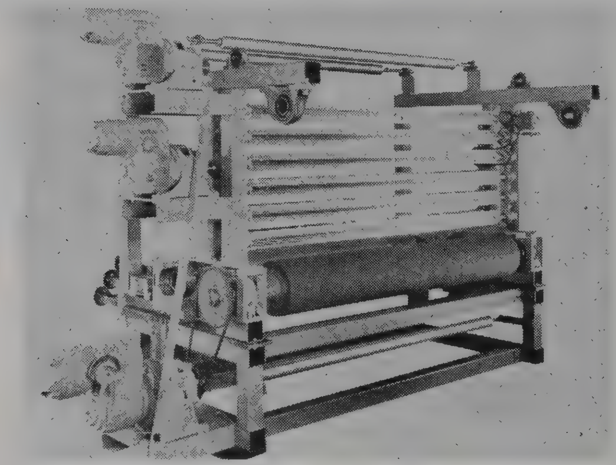

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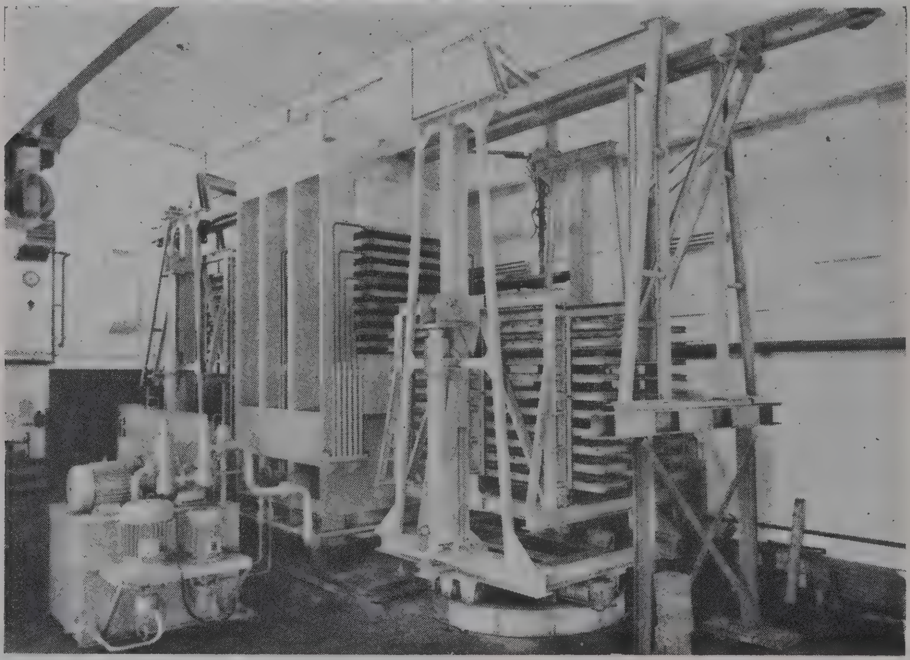

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the molded parts, and better flow.

Because of the plating characteristics of chromium, any defects in the mold surface are accentuated. This fact should be given serious consideration when setting up polishing procedures to assure good moldings.

Molds for such operations as vacuum forming, reinforced plastics molding, thermoplastic sheet forming, short-run pressure molding, etc., where mold and strength durability requirements are low, can be produced by spraying molten particles of metal onto a master until a durable shell of from ⅛ to 5⁄16 in. has been built up. This is accomplished with a special spray gun designed to feed metal rod through a high temperature flame, then blow the molten metal particles onto the pattern.

Atomic hydrogen welding

Sometimes it is necessary to build up mold parts by the addition of metal. A cutter may take out more metal than it should, or a mold part may be worn or broken off in actual use. In order to save this mold part, it has sometimes been found quite practical to weld with an atomic hydrogen torch.

Liquid honing

To speed up polishing of mold cavity parts, they are generally abrasive-blasted to remove oxidation and discolorations which have been brought about by the annealing, hardening, or carburizing operations.

This "liquid honing" is a modified form of impact blasting in which an abrasive, suspended in a liquid, is delivered to the blasting nozzle by means of a circulating pump. The suspension, shot at the work by 90 p.s.i. air pressure, gives the surface of the mold a satin-matte finish. A short polishing operation restores the desired luster.

Hardening

Practically all mold parts should be hardened before using. Equipment for this work should consist of at least one carburizing furnace, and a small furnace for odd jobs. All furnaces should be

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equipped with good instrumentation since it is important that the hardening process be accurately controlled.

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ADJUSTABLE SPEED DRIVES: Electrical

By Frank Cerra, Jr.*

There are many ways of increasing the production rate of a machine. Usually, the simplest and most obvious of these is to increase the machine speed. The optimum machine speed is seldom a fixed quantity, but usually varies with many factors. To obtain maximum production from a machine at all times and for all jobs, the speed must be adjustable to obtain the optimum speed for the particular job at hand.

Why adjustable speeds?

Adjustable speed is the characteristic which allows a drive to operate at any point within the speed range specified by the drive

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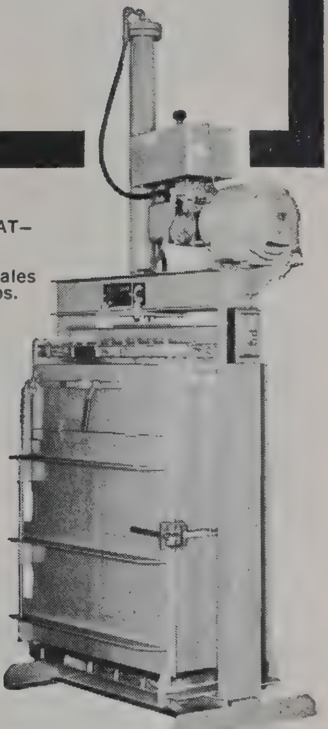

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manufacturer. This speed control is essentially stepless and provides a smooth transition from any speed within the range to any new speed selected. Because of the wide variety of materials used in the plastics industry, and their varying characteristics, practically all plastic processing machinery can benefit from adjustable speed. Different materials, when processed through the same machine, almost invariably require different drive speeds in order that optimum production with each material may be attained.

Even for a given raw material and process, uncontrollable factors can change the optimum speed of a machine. These factors, such as ambient temperature and humidity, unless compensated by a change in process speed, can affect the quality of the finished product. This results in a product which is not uniform in quality and which may require some scrapping. An adjustable speed machine also allows an operator to take advantage of unusually favorable ambient conditions to increase production.

A second major advantage of electric adjustable speed drives is their ability to maintain a preset speed under varying load conditions. This can be extremely important when elastic materials are being processed and is especially true when two or more drives must operate in tandem on the same web of material. Since preset speed can be held accurately, it follows that a preset ratio of speeds between tandem drives can also be held accurately. Plastic materials, by their very nature, require accurate speed ratio control in order to avoid stretching of the finished product.

In the plastics industry, electric adjustable speed drives are most often used for driving extruders, calenders, take-off and winding equipment, coating equipment, cutters, and laminators. Some mixing applications, where a chemical reaction also takes place, may also benefit from adjustable speed. Several machines are often combined so as to provide continuous processing of the raw material to the finished product state. Wire insulating extruders are often combined and electrically coordinated with capstan drives and windups to allow continuous processing of a reel of wire into a reel of insulated cable ready for the electrician's use. Similarly, calenders and their auxiliaries, such as cooling and drying drums, are often electrically co-ordinated with let off and windup equipment as well as coating machines. Sheet and tube extruders are co-ordinated, through conveyors, with adjustable speed cutters which cut the finished material to the desired lengths. This co-ordination increases the desirability of electric adjustable speed drives.

Once it is known that an adjustable speed drive is required for a certain application, the problem becomes one of determining which of the many available types of drives is most desirable. This is an important decision since the differences between various types of adjustable speed drives can be almost as great as the differences between adjustable speed and constant speed drives.

There are two major types of packaged electric adjustable speed drives—the eddy current coupling type and the d-c adjustable voltage type.

Eddy current coupling

The eddy current coupling is an electro-magnetic device that is used to obtain adjustable speed from a constant or variable speed source. The input shaft of the coupling must be driven by a prime mover (usually an induction motor) and a controllable source of field excitation must be provided. The output shaft speed is adjusted by controlling the excitation on the coupling field coil. Because of the inherently drooping speed characteristic, a speed regulating function is ordinarily supplied as part of this system.

Operation of an eddy current coupling is based on the principle that the current induced in a closed-conductor loop by a rotating field reacts with the field to produce torque in the direction of rotation. This torque can be produced only when there is relative motion or slip between the magnetic field and the conduc-

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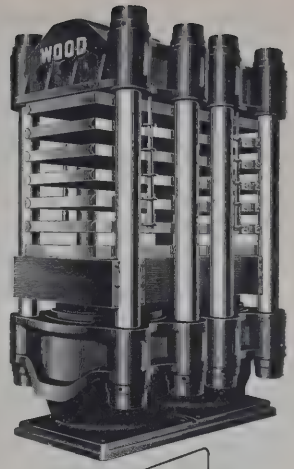
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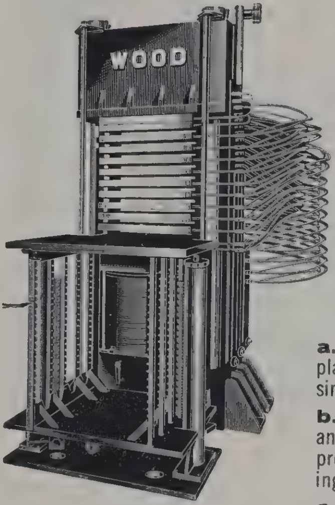
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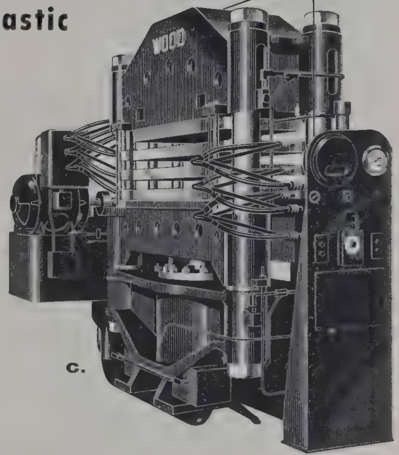
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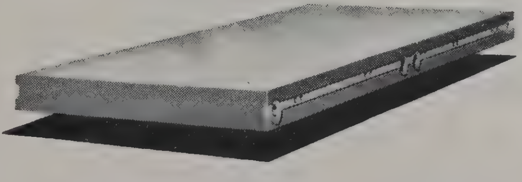
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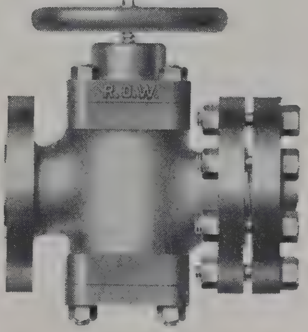
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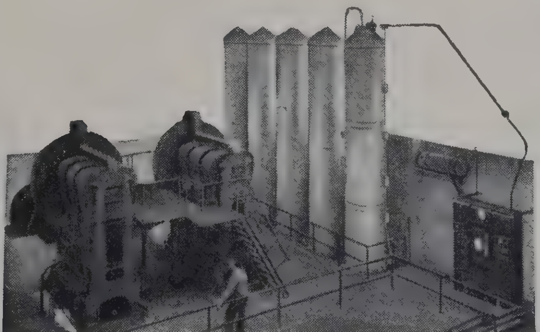
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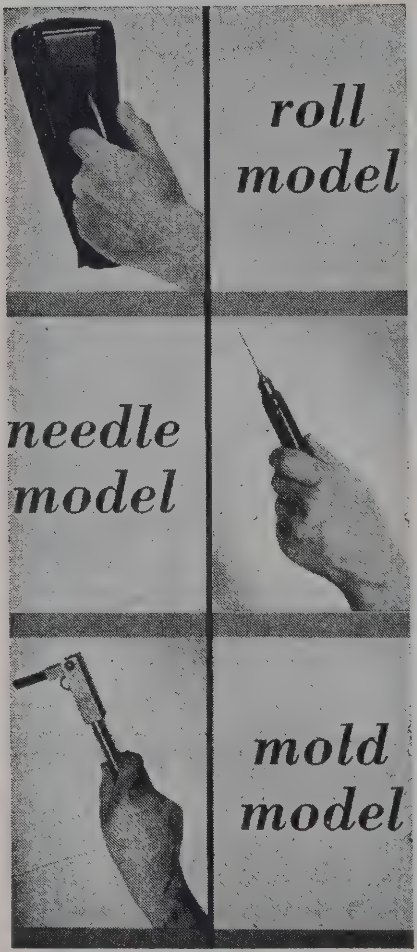

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tor loop. The amount of this slip depends on the output load torque and the strength of the magnetic field. Since output torque is substantially equal to input torque at all times, this drive is commonly considered a constant torque drive. The power at the output shaft is equal to the product of torque and output speed while the input power required is equal to the product of the input torque and input speed. The difference in power is absorbed by the coupling and appears as heat plus some friction and windage losses. These losses must be removed by a cooling medium to permit continuous operation. Since the power input to an eddy current coupling is essentially constant, it follows that the drive becomes less efficient at low speeds as slip (and thus losses) is increased. For this reason, the cooling system capacity usually determines the continuous speed range of the coupling.

Standard eddy current coupling drives are controlled from an operator's station which includes pushbuttons and a speed setting dial.

These drives are available in ratings from approximately 1 through several thousand horsepower. The standard available speed ranges for air cooled couplings are approximately 17 to 1 in the low horsepower ratings and 1½ to 1 in the higher horsepower ratings. Speed ranges can be increased by providing more efficient cooling of the coupling and/or de-rating the drive.

Since this drive is controlled by signals of a very low power level, it adapts readily to a wide range of modifications. Speed regulation of the standard drive is approximately 2%, but higher accuracies can be provided if required. The first cost of this drive is approximately 40 to 60% more than for an equivalent mechanical drive, but the eddy current coupling provides a wider speed and tension range. Tubes are used in the standard exciter-regulator but magnetic amplifier regulators are also available. It is a fairly simple drive and usually requires less space at the load than an equivalent mechanical adjustable speed drive. This is because the

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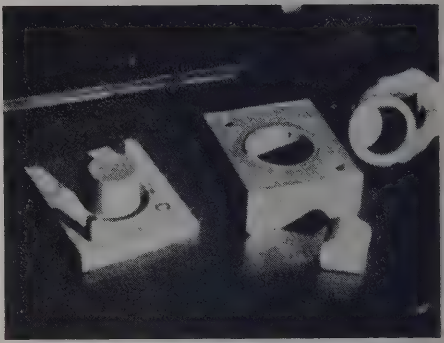

Northern Industrial Chemical Co., a leading plastics molder, used Devcon C to make a compression mold for phenolic parts in 1 hour and 50 minutes. Parts were molded at 350°F and pressure of 10,000 p.s.i.; curing cycle was five minutes. After the mold was ready, a complete experimental run was made without any change in the mold.

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control panel, which includes the excitation supply for the coupling field coil and the a-c motor control, is normally mounted remotely from the driven machine.

While the natural field of application for coupling drives is in general purpose constant torque drives, they have also been applied in a number of constant horsepower applications, particularly centerwind reels. In the plastics industry they may be used on calenders, extruders and capstans. Since their efficiency decreases with reduced speed, their operating costs are lowest when operated at or near their maximum speed. When the cooling medium is other than air, cost of the coolant and its disposition should also be considered.

Adjustable voltage drives

There are several varieties of packaged d-c adjustable voltage drives. However, they all consist of a direct current motor, an operator's station, and a power unit which includes all control plus a means for converting the shop alternating current supply into direct current. The various drives differ in the method of conversion used. The most common utilizes a motor-generator set, consisting of an a-c induction motor and a d-c generator. Standard drives are available in ratings of 1 through 500 hp. with constant torque speed range of 8 to 1 or more. The standard drive provides a constant torque characteristic since speed is adjusted by manipulating generator field excitation and thus the applied d-c armature voltage to the motor. Greater constant torque speed ranges can readily be obtained by providing a circuit to "buck out" the generator residual voltage. Standard drives are not usually suitable for continuous full load operation at the lower end of the speed range. This is because standard dripproof motors are subject to overheating under these conditions. If frequent low speed operation for extended periods is required by the process, forced cooling or de-rating of the d-c motor is usually required.

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obtained by controlling the excitation of the d-c motor field by means of a rheostat or regulator. All of these methods of increasing speed range can be accomplished at modest price increases.

A generator voltage regulator is normally supplied as a standard feature and provides 5% speed regulation. Speed regulation of as low as 1⁄10 of 1% is also available. First cost of this drive ranges from approximately 100% more (at 100 hp.) than a standard eddy current coupling drive to approximately 15% more at 10 horsepower. Maintenance is low since only periodic bearing lubrication is required. While this type of drive requires more total space than the eddy current coupling drive, less space is required at the load since only the d-c motor is located at the driven machine. Both the motor-generator set and the drive controls are located in a common steel case which is normally mounted remotely from the driven machine. Operating costs of this type of drive are low since a relatively high efficiency is attained even at low speeds.

The packaged d-c adjustable voltage drive has been used on all plastics industry applications requiring adjustable speed. It provides flexibility and accurate speed control and is generally applied in the especially critical phases of the manufacturing process. Just as with eddy current coupling drives, speed control is stepless throughout the speed range.

Types of d-c drives

The adjustable voltage system is excellent for tandem operation, since each motor may be supplied with a voltage proportional to the "line" speed required. Such a drive is very flexible in that relative motor speeds may be adjusted over almost an infinite range. Tandem drives can be made to track very closely as the machine speed is increased or decreased. Since control power levels are low, a large variety of modifications can be obtained. The motor-generator set type drive also has the ability to regenerate. This extends its usefulness since regeneration means a recovery of power to decrease power costs,

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and also to provide a readily adjusted braking torque for speed control.

A second variety of d-c drive utilizes metallic rectifiers for power conversion. In this case, the armature voltage applied to the d-c motor is controlled by magnetic amplifiers utilizing self-saturating reactors. This type of drive is available in ratings from ⅓ through 200 hp. and is similar to the motor-generator set type drive in characteristics and first cost. The only exception is that rectifiers can carry current in one direction only and therefore do not have the ability to regenerate. They should therefore not be used on overhauling type loads or where a regenerative stop is required. The recently developed silicon rectifier is now commonly used. They must be applied carefully, but indications are that long reliable life can be expected as no aging characteristics are shown. Silicon rectifiers have considerably increased the attractiveness of the rectifier conversion unit.

The third type of d-c drive utilizes electronic tubes for power conversion. These drives are available in ratings up to approximately 100 hp. but are most often used in ratings below 10 hp. They display the same general characteristics as metallic rectifier drives and are approximately equal in first cost. Normal maintenance consists of electronic tube replacement and lubrication of the drive motor bearings.

ADJUSTABLE SPEED DRIVES: Mechanical

By G. D. Campbell*

EDITORS' NOTE: *The foregoing article on adjustable speed drives (electrical) outlines the need for such machine controls in the plastics industry, and describes methods of achieving the desired end by electrical means. The following discussion covers briefly a mechanical adjustable speed drive, and summarizes the factors to be*

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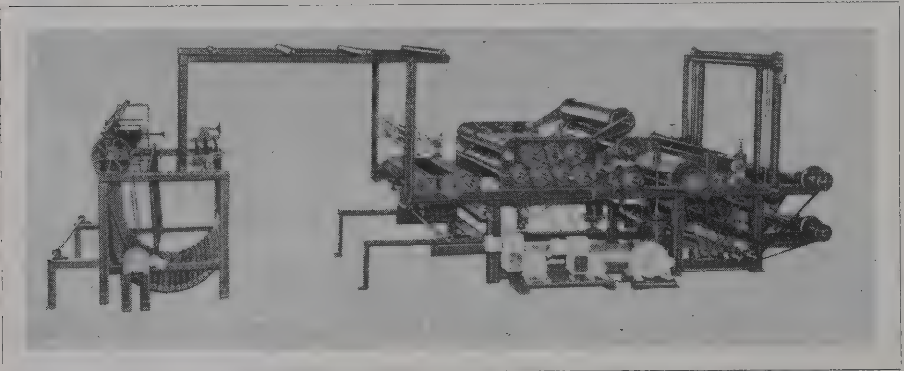

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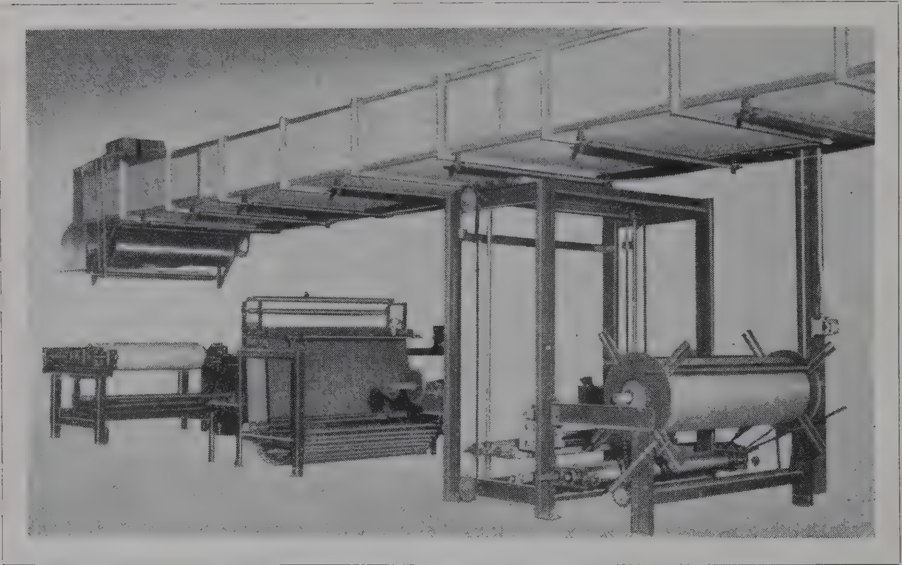

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considered in choosing a drive system—either electrical or mechanical—that will best fulfill the requirements of a given extrusion operation.

The mechanical drive offers an inexpensive method of varying machine speed. The variable-pitch pulleys are made up of two sets of cone-faced disks. These driving disks, which are splined to parallel shafts, are constantly tensioned against the belts and are movable laterally on their shafts by means of two levels, which are pivoted midway between the shafts, and are moved by an adjusting screw which has a left and right-hand thread. The control of the disk positioning levers may be accomplished either manually by a hand wheel and screw, or remotely by a chain drive. If automatic operation is required, the hand wheel is replaced by a speed-changing screw, controlled by an all-electric or differential system.

Speed regulation is adequate, rarely exceeding 5%, and the speed range is limited to approximately 6:1 in the smaller horsepowers and 4:1 in the larger horsepowers. The complete unit sits at the input shaft of the extruder, and requires more floor space at the point of application than electric adjustable speed drives. Mechanical drives are most commonly applied to extruders requiring approximately 40 hp. and below. Mechanical or pneumatic devices can be utilized to synchronize this drive to any other machine section. The drive is essentially a constant-torque drive.

Choosing a drive

Before purchasing an extruder, the user should make every effort to define the range of materials he expects to handle.

The extruder manufacturer can then better define what equipment should be supplied along with the extruder, such as take-away equipment, heating controls, proper screw design for the job, and the proper type and size of drive to be used.

For simple, straight-through extrusions of profiles and shapes where tolerance is not continually critical, the mechanical drive will do the job for a low first cost, but has disadvantages, such as limited size and limited speed ranges (up to 6:1).

For coordinated drives, such as wire-coating lines and extruder-laminator drives, the all-electric drive presents a more versatile approach. It is compact and can be conveniently "tucked away" to conserve installation space. It also offers a wide speed range and regulation as precise as 1/10 of 1 percent.

Performance and reliability of the driving equipment, its ease of maintenance, and availability of competent service assistance when required, should all be carefully considered.

Finally, most extruders require a wide speed range. Both constant-torque and constant-horsepower drives have their place. The last, and probably most important, factor to be considered is cost—both first cost and operating costs, which include maintenance. Careful consideration of all these points will insure that you get the proper extruder drive to give best production results under your own particular operating conditions.

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For Predrying Molding Powders*

As pointed out in several of the preceding articles on injection molding and extrusion of thermoplastics, some materials require drying before processing to insure perfect molded and extruded parts and sections.

The cellulosics, nylons, and acrylics may absorb moisture from the shop air. While nylon compounds are packaged in sealed tins to prevent water pickup during transit and storage, they must be used very soon after breaking the seal to avoid trouble. Contents of cans left open for more than half an hour in humid air should be dried before use, and so should all reground scrap. Makers of cellulosics recommend drying as a regular procedure before extru-

---

*Based on information from F. I. McCosh, Thoreson-McCosh, Inc., Detroit, Mich.

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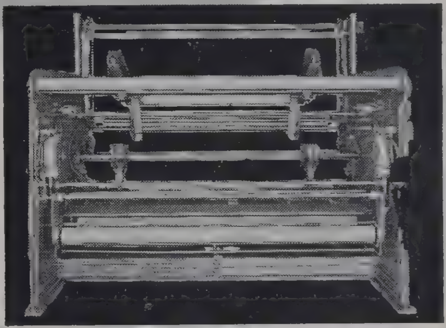

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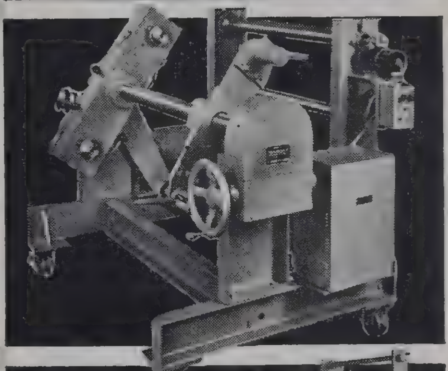

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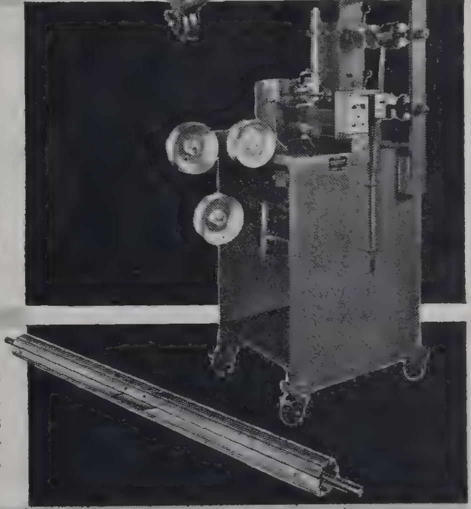

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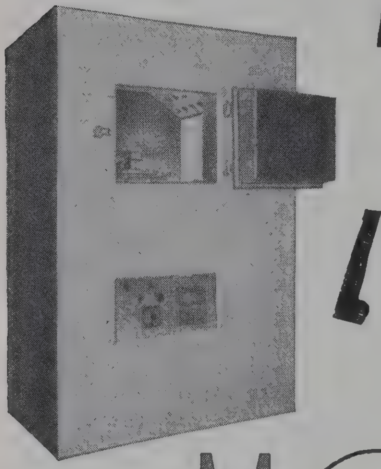

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sion, unless a two-stage vented extruder is used. Hot-air drying incidentally preheats the material, reducing power requirements, and, in many instances, increasing machine output.

Polystyrenes, vinyls, and polyethylenes do not absorb water into their mass as do the materials mentioned above. On humid days, however, they may exhibit moisture troubles and it is assumed that the surfaces of the particles *ad*sorb water. Standard drying procedures remove this surface moisture easily.

How to dry

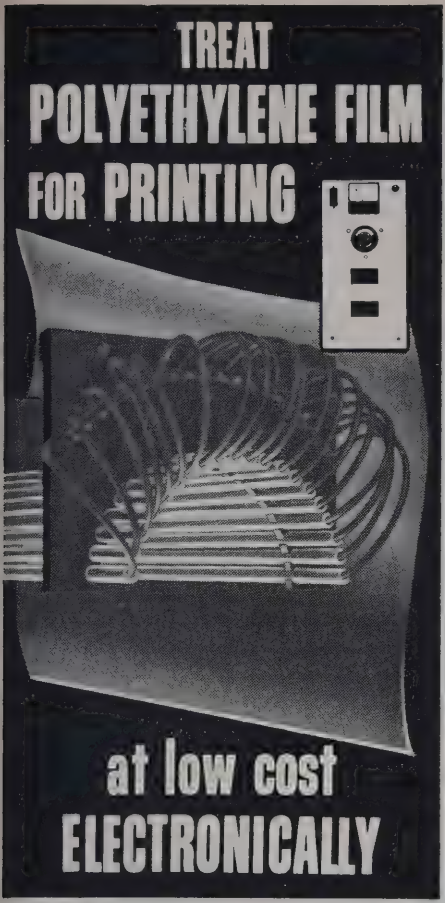
Two methods are in general use for drying molding and extrusion compounds—the circulating-hot-air oven and the hopper-dryer.

The hot-air oven consists of a series of trays in a closed chamber around which air is circulated by convection or forced with a blower. A small fraction of the warm air is allowed to escape and new air is bled in, to prevent accumulation of moisture in the air. Some ovens are fitted with dehumidifiers that remove a percentage of the moisture from the bled-in air.

With a hopper-dryer, the air is forced through the material as it rests in a hopper that is either mounted directly on the extruder or molding machine, or separately mounted on a floor stand.

With either method, the correct amount of air at the correct temperature must be in contact with the material particles for a sufficient length of time to accomplish satisfactory drying.

Unfortunately, very few data are available on *rates* of moisture loss from molding powders under the conditions prevailing in commercial drying equipment. In those resins which will pick up water from humid air, equilibrium with the surrounding air is eventually reached and water content increases as the humidity increases. The equilibrium point also depends on the temperature, the water pick-up decreasing with rising temperature. To reduce the water content of the material, it must be brought into contact with air at such a temperature and humidity that the equilibrium water content is lower than its present



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water content. If the reverse conditions are set up, the material can actually be un-dried, i.e., it will pick up more water.

If in the dryer there is good contact between the air and the particles and if the air is moving over the particle surfaces at a reasonable rate, the rate of drying is probably governed by the rate at which water diffuses out of the plastic particles to their surfaces. If, however, the air at the surface is stagnant or very sluggishly moving, it may become saturated with water. The outward-diffusing water then begins to diffuse back in and no further drying is accomplished.

Raising the temperature helps in several ways. First, it increases the diffusion rate. Second, it increases the capacity of air to hold water. (Air at 70° F. holds only 0.0158 lb. of water/lb. of dry air, while at 175° F. its capacity is more than 30 times this figure.) Third, in the case of materials whose water content is in equilibrium with that of the air, this equilibrium, as was said earlier, is shifted in favor of drier material by raising the temperature. Of course, the temperature cannot be raised indefinitely, else the plastic may soften or be oxidized. Unfortunately, oxidation is also accelerated by rising temperature. Drying temperatures of 175° to 200° F. are recommended by the makers of nylons, cellulosics, and acrylics. However, cellulosics have a tendency to cake in the dryer when heated above 160° F., so that it is better to dry below this figure.

Intake air drying

The air bled into the oven need not be dried if the molding powder is not hygroscopic, even on the most humid of hot summer days. To see why this is so, it is only necessary to recall the tremendous water-carrying capacity of hot air. Air entering at 100° F. and 90% relative humidity contains 0.038 lb. water/lb. dry air. Air at 175° F. can carry 0.53 lb. water/lb. dry air. Thus the entering air can pick up over 0.49 lb./lb. If it were dehumidified to perfect dryness, its pick-up limit would be 0.53 lb./lb.; therefore, drying the intake does no ap-

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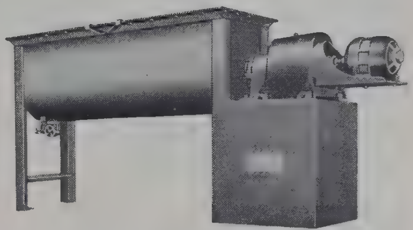

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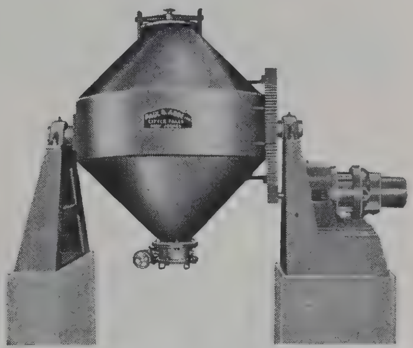

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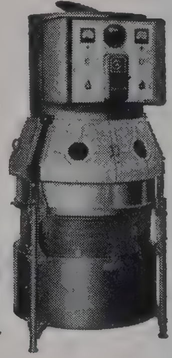

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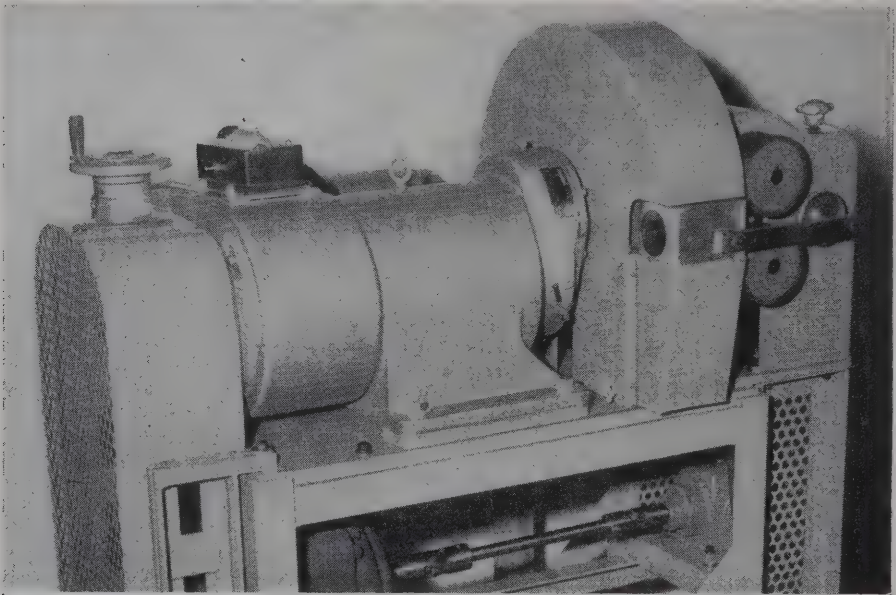

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preciable good when drying materials containing surface moisture or one like polymethyl methacrylate, whose equilibrium level at these conditions seems well below the satisfactory limit for processing.

At the other end of the scale are the nylons, both type 6/6 and type 6 being extremely hygroscopic. The equilibrium data have been determined for nylon 6/6 and this information[1] is the basis for the following discussion.

Depending on the requirements of the particular job being done, the water content of the molding powder will usually have to be somewhere between 0.15 and 0.28 per cent. Taking 0.20% as an example, air entering the oven at 70° F. and 40% R.H., typical indoor winter conditions in the U.S., is theoretically able to dry the 6/6 nylon down to about 0.13% water, and so should easily get it to the 0.20% level. On the other hand, air entering at 90° F. and 80% R.H., a condition frequently encountered inside U.S. molding plants in the summer, cannot get the resin any drier than 0.48% water, no matter how long a drying period is used. Worse yet, if nylon containing 0.30% water were kept in the "dryer" long enough under these conditions, it would actually be *undried* to 0.48 percent! Clearly, the entering air must be dehumidified when drying hygroscopic materials during hot, humid days. In fact, if 0.20% water in 6/6 nylon is the level sought, air at any absolute humidity exceeding 0.010 lb. water/lb. dry air will require predrying. This corresponds to air at 70° F. and 63% R.H.

Types of dehumidifiers

Two methods of dehumidification—chemical and mechanical—are in common use, and dehumidifiers of either type are available for use with drying equipment.

Chemical types, which use silica gel or some other desiccant, if operated at the proper rates, can get the air extremely dry, but require frequent regeneration. In practice they are conveniently used in pairs, one being on stream while the other is being regenerated, i.e., dried, by very hot air. For effective operation the air to be dried by the desiccant must be cooled to about 100° F. If the hot air in the dryer is kept dry by recirculating it through the desiccant, it must be cooled below that temperature and, of course, reheated in the dryer. This means wasting a good bit of heat. However, recirculation with cooling may be more economical on humid days than the more frequent regeneration required by continuously drawing in fresh moist air. Desiccants used in these dehumidifiers sometimes suffer from loss of effectiveness in drying of plasticized or monomer-containing resins. Apparently these organic compounds and/or their oxidation products are not completely removed during the regeneration cycle.

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[1] Bulletin No. X-84a, "Comments on the use of drying ovens (for 6/6 nylon)," Polychemicals Dept., E. I. du Pont de Nemours & Co., 1956.

The other method of dehumidifying the air is to refrigerate it one way or another, as is done in air-conditioning equipment. Most of these mechanical dehumidifiers deliver air at 60° F. and 100% R.H. In this condition it can theoretically dry 6/6 nylon down to 0.23% water, though with this entering air it will probably take an inordinately long time to achieve any level below 0.25 percent. This water content should be satisfactory for most molding jobs, but where the material must be drier, the chemical dehumidifier or a special low-temperature mechanical dehumidifier will be needed.

For Cooling Water Conservation*

The cooling operation in plastics processing—injection molding, extrusion, embossing, coating, vacuum forming, etc.—is an important function that can increase production, improve quality, and result in a reduction of rejects. There are several types of cooling units available, at least one of which is based on the use of recirculating water to cut cooling water costs drastically.

In a typical installation, the process water is reclaimed and

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*Based on data supplied by Mayer Refrigerating Engineers, Inc., Lincoln Park, N. J.

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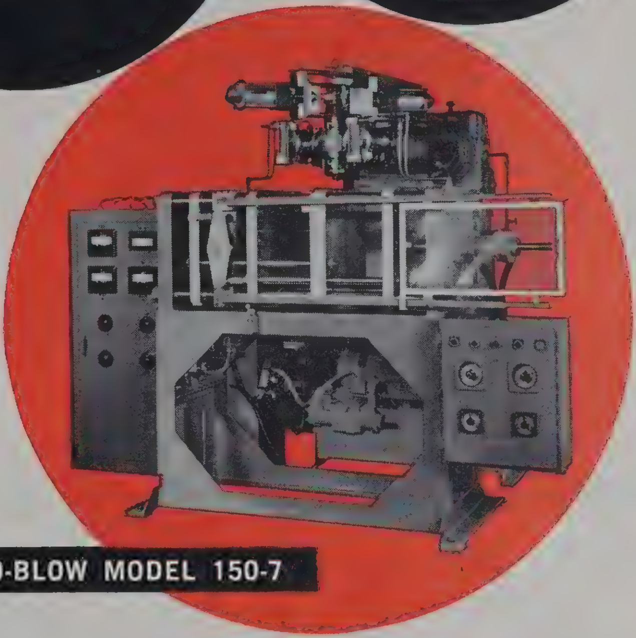

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recooled by being recirculated through an evaporative type cooler. The reclaimed water is pumped to the top of the unit where it flows by gravity over baffles. It is cooled by blowers which draw air through the baffle openings, then pumped back to the process equipment.

A unit of this type can be used where summer process temperatures of 85° F. are satisfactory. Where lower temperature cooling is required, in addition to the water savings effected by recirculating units, the recirculating units can be used in series with a special refrigeration chilling unit that will lower the temperature of the water from 85 to 40° F. before it is passed through the equipment to be cooled.

Water used direct from a city supply and discharged to the sewer is expensive; the overall cost can be reduced greatly with recirculating units of this type; it is estimated that the units can save up to 95% of water consumption. A slight loss occurs due to evaporation, windage, and a small overflow to keep the water clean.

It is also claimed that, as a temperature control device, the recirculating and chilling units can result in an increase of from 10 to 30% in plant efficiency. One molder claims an increase in plant efficiency of 30% and an increase in cycles of 32% with the installation of the recirculating units. Another manufacturer who turns out calendered vinyl at the rate of 35 to 65 ft./min. reported an increase up to 75 ft./min. with the installation of a cooling unit on the calendering roll.

For Granulating*

Scrap thermoplastic material—gates, runners, sprues, and rejects—can be salvaged for re-use in most injection molding and extrusion plants. Efficient grinders or granulating machines make such salvage especially attractive in cases where the weight of the scrap may be even greater than that of the finished plastic part.

There are two general methods of employing granulators: 1) beside-the-press and 2) in a central

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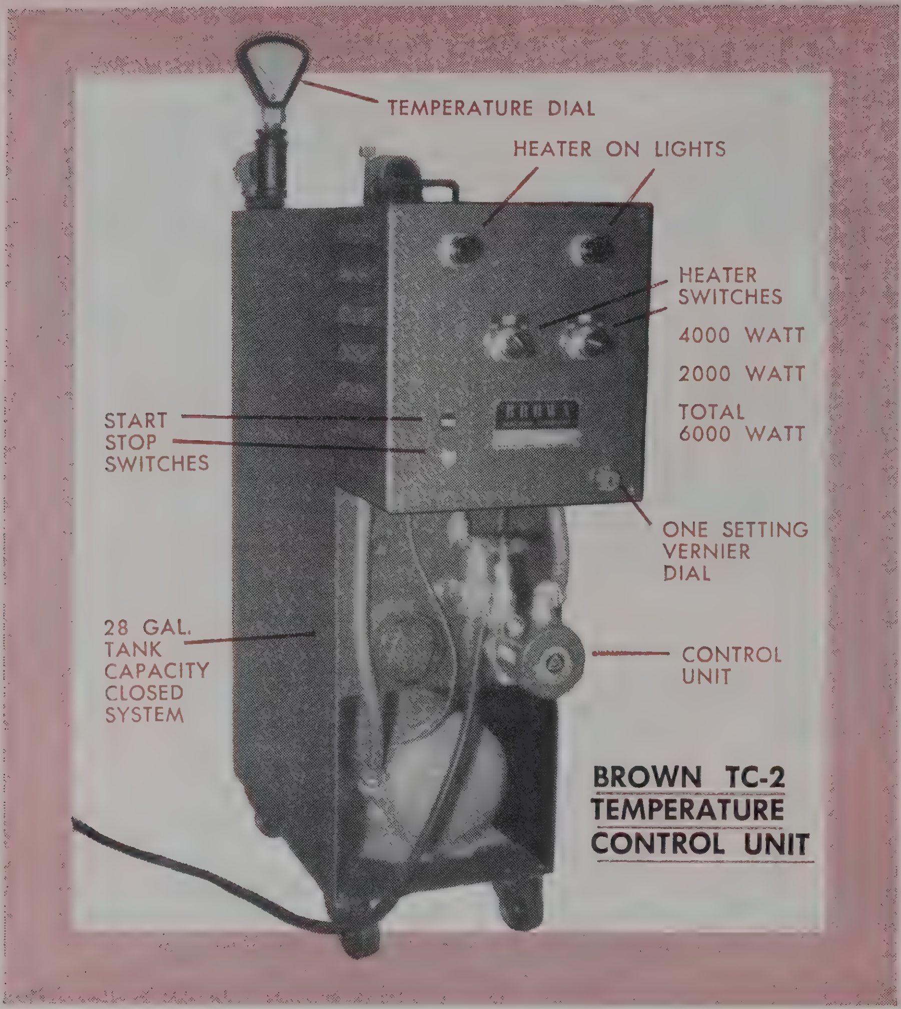
*Based on information supplied by Charles W. Ball, sec'y and treas., Ball & Jewell, Inc., Brooklyn, N. Y.



Constant and exact temperature control is easy with the **BROWN** closed system unit

Brown Machine Company, continuing to serve the plastics industry with dependable modern equipment, proudly introduces the new TC-2 Control Unit. The Brown TC-2 is an improved recirculating closed-system temperature control unit. Its function is to maintain a stable surface temperature for all types of Vacuum Forming Molds and Sheet Polishing Rolls within ±1.5°F. Simple to operate, the TC-2 assures constant precise control at all times; and is extremely economical to use because of its efficient recirculation system. If you want accurate temperature control (to ±1.5°F.), with low operating and maintenance costs, let the new TC-2 unit do the job for you.

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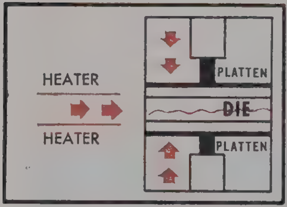
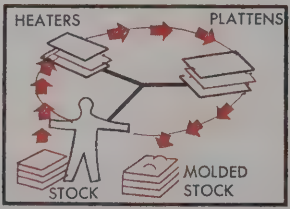
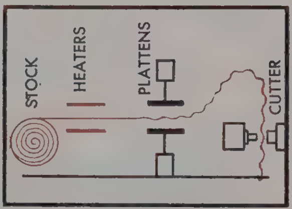


2 STATION MODEL 222



ROTATING MODEL 223



CONTINUOUS MODEL 22C

FOR FURTHER INFORMATION, ADDRESS ALL INQUIRIES TO
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grinding room. Beside-the-press installations make possible immediate regranulation of scrap, thus saving storage space and extra handling. Also, the salvaged material can be returned at once to the injection machine or extruder hopper by means of an automatic conveying and loading device with which some types of grinders are equipped. Such automatic set-ups can also be obtained to proportion and mix the reground scrap with virgin material. In addition, by the use of separate grinders, different materials or colors of materials can be reground without danger of contamination.

Central grinding rooms usually are equipped with larger granulators for handling bulk accumulations of scrap. While this system is preferred by many molders, it is obvious that it requires more handling of the scrap and presents problems of sorting and guarding against contamination.

The requirements for grinding equipment will vary, depending upon the type of plastics materials used and the size and weight of the scrap material to be reground. Such details as thickness of materials, over-all sizes of pieces to be ground, and capacity required will, of course, influence the choice of a suitable grinder. Many types and models of plastic granulators are available on the market today, and thorough investigation of all makes of machines is recommended before reaching a decision as to which machine would best meet individual requirements.

For Weigh Feeding*

The advantage of the weigh feeder on an injection molding machine is the elimination or reduction of rejects—which saves molding material and improves the overall quality of the machine output. The weigh feeder also makes it possible to save material by filling the mold with an exact minimum quantity of plastic required. There is no packing when this starve-feed principle is used, and controlled wall thicknesses result. When the weigh feeder is set for starve feeding, quality is improved because the bottoming

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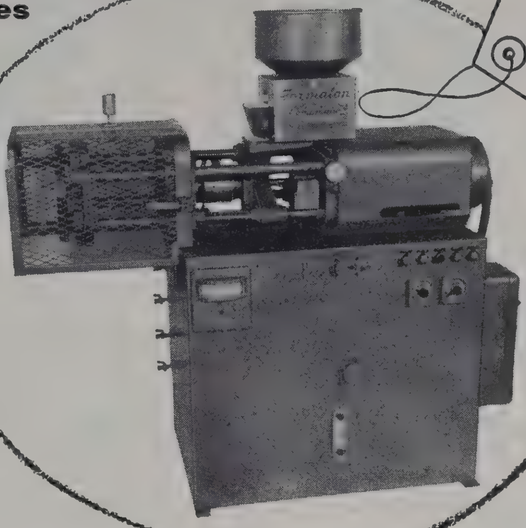
*Based on information supplied by The Exact Weight Scale Co., Columbus, Ohio.



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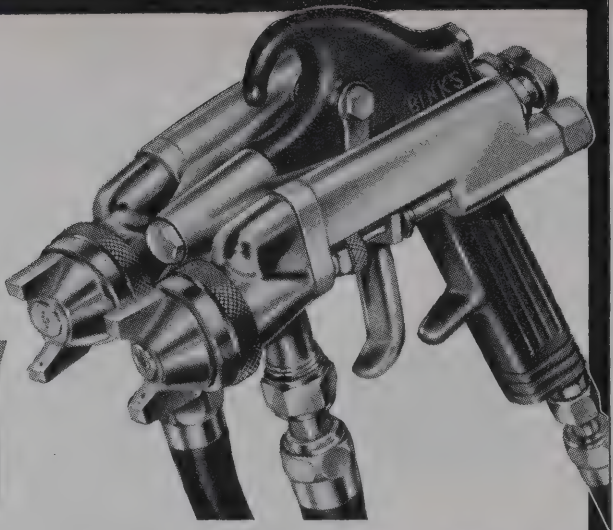
plunger causes pressure within the mold to be uniformly distributed and internal stresses in the molded part are eliminated. Higher injection pressures can be used for faster injection; since the exact required amount of material is injected there is no mold flash, regardless of pressure. By removing one important variable in injection molding—the quantity of material injected in one shot—and automatically correcting for others, starve feeding can minimize rejects.

Another method of using the weigh feeder involves the cushion-feed principle. When cushion feeding, the feeder is set to save material by maintaining a uniform cushion. Pressure within a mold will vary as the cushion varies; a uniform cushion makes it possible to adjust injection pressure to an optimum value. Some weigh feeders for injection molding machines are equipped with automatic plunger position controls which maintain the forward limit of the plunger travel by varying the amount of plastic delivered in accordance with the demand from the molding machine.

Case histories

The production value of weigh feeding to the injection molder interested in reducing rejects and improving quality is indicated by the following summary of three recorded case studies:

One molder reports that the equipment paid for itself in a few months because of increased production through elimination of rejects caused by short shots; production increased 7½% and rejects dropped from 10% to 2½ percent. Another report shows a decrease in cycle time by 7 sec. per shot; increased part quality through the use of higher injection pressure; and virtual elimination of rejects. The third case study reveals a reduction in overall cycle time from 72 to 52 sec.; an increase in production rate from 400 pieces per shift with an average of 60 rejects to 550 pieces with no rejects; and a saving of 3¼ oz. of material per 18¾ oz. piece (formerly 22 oz.) because no packing occurs with weigh feeding.



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For Compounding and Coloring

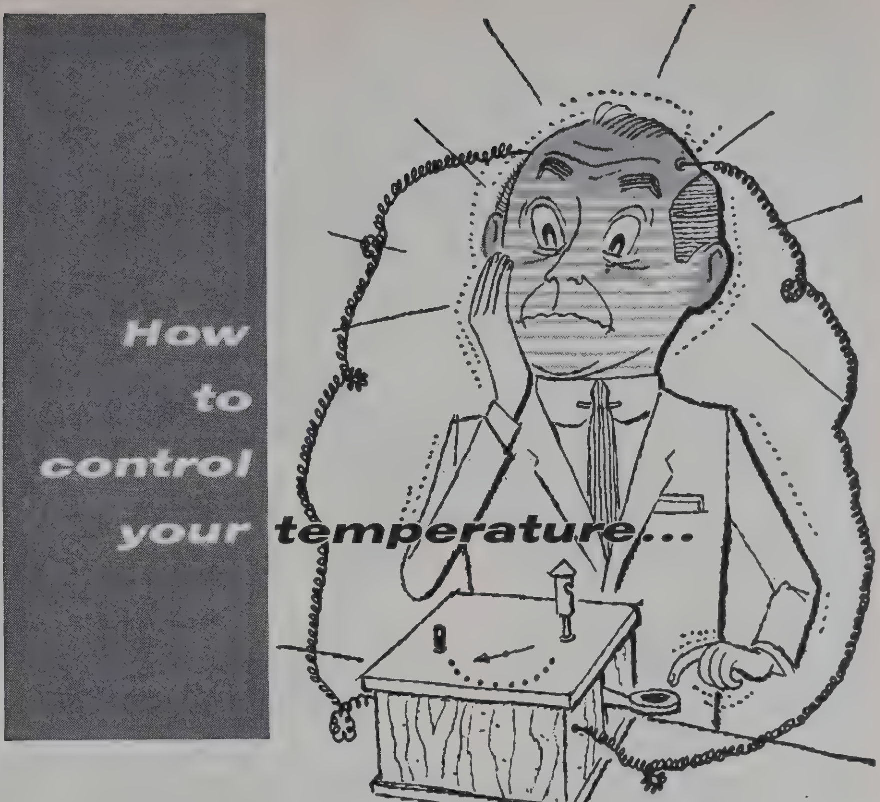
In general, compounding and coloring thermoplastics requires at least four steps: 1) weighing ingredients, 2) mechanical blending, 3) plasticating the mixture, and 4) cutting the finished compound into useable particles. At least one piece of equipment will be required for each step. Not infrequently, where a particularly thorough mixture is desired, two types of equipment—a Banbury mixer and milling rolls—will be employed for plasticating the material.

The choice of equipment for each of the four compounding stages will depend in part on the quantity of compound desired and the speed of production. The nature of the thermoplastic being compounded and of the other ingredients will also play a part. Finally, the form in which the compound is to be fed to the molding or extruding machine will affect the choice of equipment to be used for the final cutting operation.

Weighing equipment is required for the first step in any compounding or coloring operation, unless the desired proportions happen to be such that the batch can be made up from preweighed contents of bags, drums, or other shipping containers. Even in such a case, check-weighing may be desirable to assure accuracy.

The type and size of scales used will vary widely with the nature of the operations. For the coloring of polystyrene crystal in a molding plant, small balances will generally be all that are necessary to weigh out the small amounts of colorants required. At the opposite extreme are the large enclosed scales required by materials manufacturers.

In any compounding or coloring operation, the properly weighed amounts of the various ingredients must first be mechanically blended before the mixture can be satisfactorily masticated. The material in the premixer may be wet or dry, depending on the type of plasticizer used. Some premixers can handle either wet or dry mixtures, while others are suitable only for dry blends.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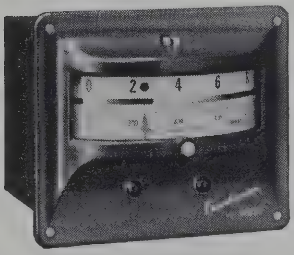

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Another major distinction may be made between mixers with internal moving elements to do the mixing and those in which the whole mixing chamber revolves.

Tumbling blenders: The tumbling blenders, which handle only dry mixes, are of many types, but in all of them the mixing is achieved by some type of turning action of the chamber containing the mix. One type is mounted on a horizontal axis and turns end-over-end vertically. In another, the steel drum is mounted on the machine base so that it rotates at an angle of about 30° from the vertical. In still another tumbling unit, the drum is mounted at an angle to the horizontal shaft and is balanced by another drum at the opposite end of the shaft.

None of the tumbler containers have moving elements, although some types have curved baffles affixed to their internal walls to direct the material from one end of the barrel to the other as it is revolved.

A centrifugal-type mixer which was originally developed for use by food processors is suitable for blending batches of dry mixes. This machine has an enclosed motor which drives a directly-connected rotor at high speed.

Ribbon blenders: Another type of premixer employing internal moving elements to effect the blending is a ribbon blender, which can be used with either wet or dry mixes. The mixing action is accomplished by several equally-spaced helical blades, rotating on a horizontal axis in an enclosed trough. The trough contains a top opening for feed purposes and a bottom port for discharge.

Plasticating equipment

After the initial premixing of the components of a molding compound in a blender, it is usually necessary that the mixture be worked into a soft (molten) state under heat and pressure. Among the intensive-type mixers suitable for plasticating are the Banbury, intermix, and spiral flow mixers, mill rolls, and extruding machines.

Intensive internal mixers: These generally consist of a mixing chamber containing two revolving rotors. Clearance between the

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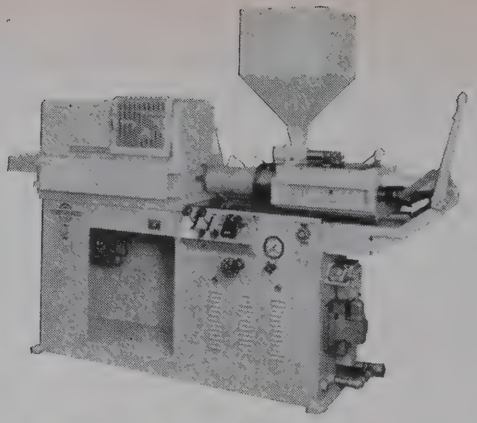

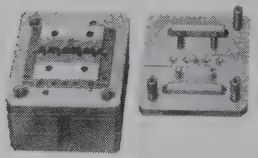

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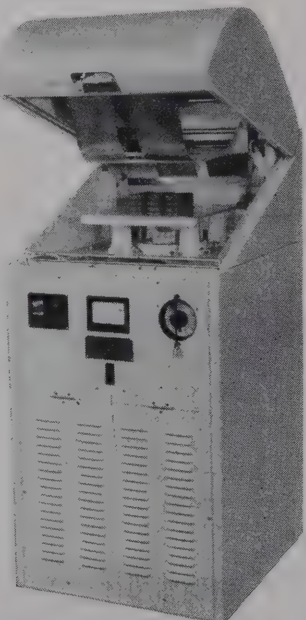

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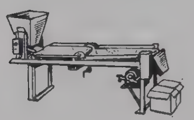

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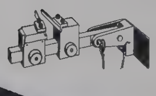

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rotors and the wall of the chamber is small, assuring thorough mastication of the material between them. The material is charged into the chamber through a hopper. Generally, the mixer is equipped with a pressure ram which, when activated, forces the material into the rotors. Most mixers of this type are cored and jacketed for circulating a liquid heating medium.

Milling rolls: A set of milling rolls consists of two steel rolls, cored for the circulation of steam or other heating medium. The rolls are usually horizontal, parallel, and equidistant from the floor. They rotate slowly toward each other. The roll nearest the operator is known as the "mixing roll"; it turns slightly faster than the other roll and is cooler. The space between the two rolls can be adjusted by the operator to exert the desired amount of pressure. Doctor blades attached to the rolls, or ordinary knives, can be used to cut the blanket of material adhering to the mixing roll so that it can be mixed further.

Multi-screw extruders: Twin-screw extruding machines are often used for compounding and coloring thermoplastic molding material. When used by injection molders, the material is generally extruded in the form of multiple rods or spaghetti which may be cut right at the face of the die, or may be conveyed through a cooling bath and thence into a pelletizer. When such a setup is used by extruders, however, it makes it possible to compound, color, and extrude into the desired section in a single operation. Two general types of these multi-screw extruding machines are now being marketed in the U.S., one manufactured in this country and one abroad.

In each machine, both worms participate in the kneading and heating operation, but in the American machine, the actual extrusion is effected by only one screw, the other one being shorter in length. In the foreign machine, the flights on the two screws are of the same pitch, permitting them to mesh, but in the American machine the worms do not mesh. The material is plasticated by the pressure and heat as it is forced against the heated cylinder wall by the revolving screw, and as it is advanced along the flights in the screw toward the front of the chamber. On both machines, the screws are machined with progressively finer flights, to handle the material as it becomes more thoroughly melted in the cylinder.

The size and shape of the cylinder chamber on each machine corresponds to the requirements of the screws. Thus, while both chambers are ∞ shaped at their feed end, the one in the American machine streamlines down into a conventional round shape at the discharge end, due to the fact that only one screw extends into the final section of the chamber. On the foreign machine, the ∞ shape persists throughout the chamber length.

Single-screw extruders: Some single-screw extruders, with worms especially designed to work the material thoroughly, are also used to compound and color thermoplastics.

Chopping, granulating, dicing

Theoretically, any crushing, grinding, or cutting equipment could be used for reducing thermoplastic compound to a size suitable for feeding into an injection machine or extruder hopper. In a specific case, the choice of cutting equipment will depend partly on the plasticating equipment that has been used and partly on the size and shape desired in the particles. Thus, compound coming in sheet-like form from mill rolls is usually broken mechanically, then fed first to a chopper where it is cut into large pieces, then to a granulator where the large pieces are converted into granules or powder. In contrast, rods of compound that come from an extruding machine are customarily cut by a pelletizer.

Choppers: The function of a chopping machine is to reduce continuous material, such as extrusions or sheets from mill rolls, to a size that can be conveniently handled by a granulator. The sturdy machine in which such rough, nonuniform cutting is accomplished is equipped with a series of rotating knives cutting against a bed knife. In fact, its

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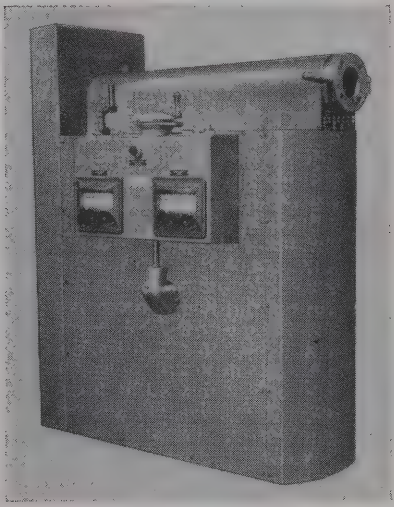

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operation is similar to that of a granulator.

Granulators: The machines used for final granulation of the material are generally grinders or dicers. Scrap grinders may be used for granulation of virgin stock. Materials manufacturers require heavier machines, of greater capacity, though built on a similar principle. Some of the heaviest granulators may obviate the preliminary use of a chopper.

The cutting chamber of a typical granulator consists of a motor-driven rotor containing revolving tool-steel knives which cut against fixed stationary knives that are set at a slight angle in the cheek pieces. The size and number of both rotary knives and stationary knives will vary with the size and requirements of the machine. The bottom of the cutting chamber consists of a perforated screen. The size of the holes will determine the maximum size of the particles leaving the machine, which may vary from 5/16 in. down to a fine powder.

Dicers: Whether a pelletizer or dicer is selected will depend largely on the form in which the plastic is to be fed to it. Thus, the multiple rods emerging from a compounding extruder are already of the desired diameter, so the pelletizer merely needs to be capable of performing one operation—cutting the rod into the desired lengths. When the stock is to be cut hot, the pelletizing device, called a fly-knife cutter, may be located grazingly close to the face of the extrusion die, which feeds directly into it. The die face acts as one "blade" of the so-called "scissor."

If the extruded rods or strips are to be cut cold, the pelletizer must be equipped with feed rolls to assure positive feed; constant rate is necessary if pellets are to be of equal lengths. The cutting blades revolve at right angles to the direction of feed.

When the stock to be pelletized comes to the machine either in the form of a sheet from milling rolls or wide strips from an extruder, the machine must be capable of cutting it both lengthwise and crosswise. Special dicing machines are made for this type of work; also available are slitting

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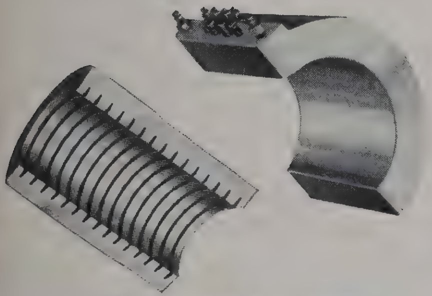

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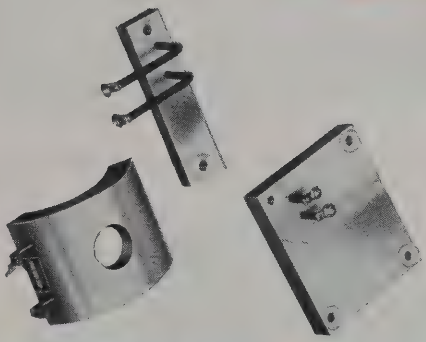

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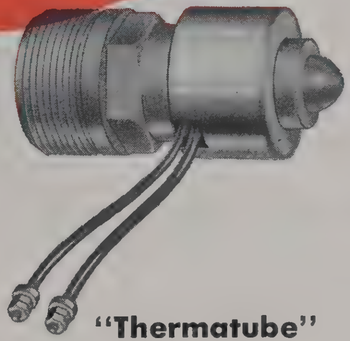

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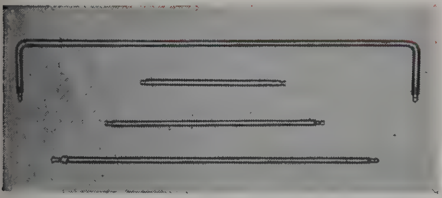

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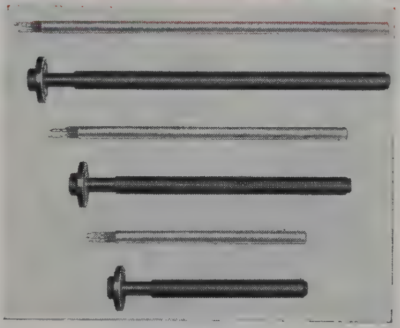
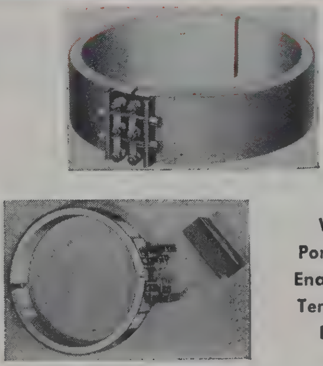


CAST INSERT IMMERSION HEATERS



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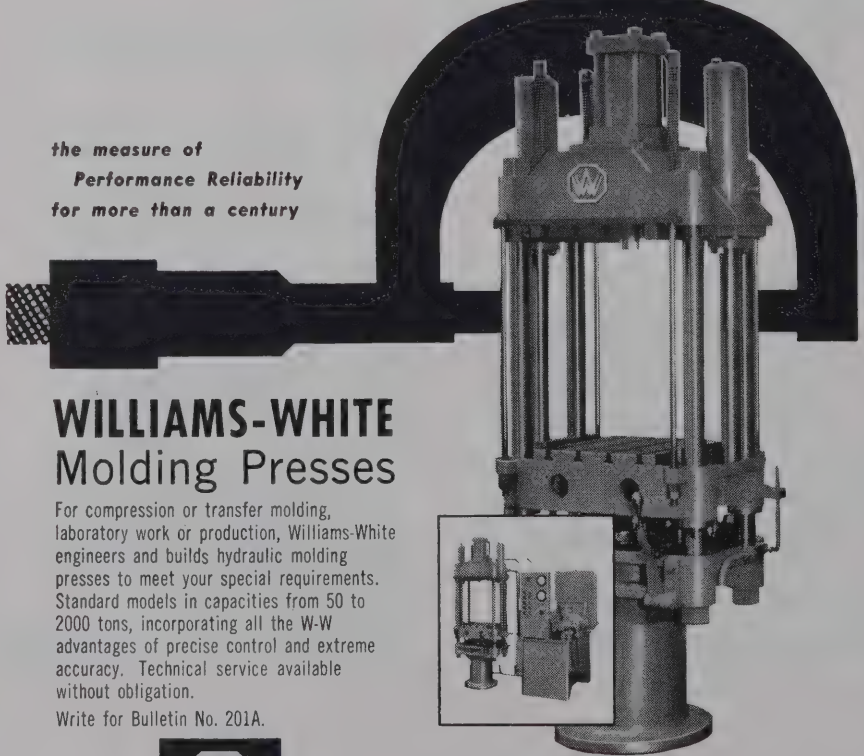

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attachments for use on ordinary pelletizers. One machine, particularly suitable for cutting elastomeric materials but adaptable to rigid thermoplastics if they are fed warm, has a saw-tooth slitting roll instead of the feed roll common to the rotary chopper which is used for pelletizing the rods.

For further information on colorants, see p. 322. Also consult the Subject Index. For sources of compounding equipment and colorants, see the Directory Index, p. 1078.

For Preforming Thermosets

Equipment for preforming is divided into two general classifications. One is the type used by a compression or transfer molder for producing dense pills or preforms from powdered or granulated molding material, or from impregnated chopped fabric thermosetting compounds. The second classification is used only by the molder of reinforced plastics, and its function is to produce a preform of chopped glass fibers in the approximate shape of the desired end product.

This article will treat with the first type of equipment. Preform machines for reinforced plastics molding are discussed on p. 478. molding are discussed in the article appearing on p. 478.

Types of presses

There are two methods of classifying preform presses. One distinction is on the basis of single-stroke or rotary design, the other on the basis of mechanical or hydraulic operation. All types have variable-speed drives and means for adjusting the weight and density of the preforms.

In general, in the standard automatic, mechanical single-stroke press, a volumetrically determined charge is fed into a stationary die cavity by a reciprocating or oscillating feed shoe. The hydraulic single-stroke press, on the other hand, is semi-automatic and the operator loads a measured charge into the die before the start of each cycle.

Single-stroke presses are available in capacities of up to 200 tons; the largest size is capable of making preforms 28 sq. in. in area and weighing as much as 2½ lb. each at a speed of 45 or 50 per minute. A 75-ton press has satisfactorily produced ⅛-in. diameter preforms at the rate of 10,000 per min. in a 160-cavity die.

The single-stroke presses are particularly well-suited to the needs of molders who have a wide variety of preform requirements, because both large and small preforms of various contours can be made with equal facility on the same machine, and because die changes can be accomplished with a minimum of downtime.

Rotary presses

Rotary presses employ a number of die sets, mounted on rotating members. Ejection of the preforms is accomplished by cam actuation of the lower punches.

As in the case of single-stroke presses, charges for the rotary presses are volumetrically determined. However, in rotary presses, the dies do not remain stationary for filling as they do on single-stroke presses. Instead, the cavity is filled by moving it underneath a stationary material feeder.

Even with single-cavity die sets, production on a rotary is fairly high. In a single revolution of the die table, one or two pills are produced per die set, and there may be as many as 33 of these die sets on the die table.

Rotary presses are available in capacities up to 100 tons. The largest machine is capable of making 60 six-in.-sq. preforms per minute. Special presses designed to accommodate multiple-cavity die sets have turned out as many as 4000 preforms per minute.

Changing the die sets on a rotary press requires considerably more time than on a single-stroke press; however, molders find the rotary type of press to be economical for long production runs.

Production requirements

When the molder customarily produces a variety of end products in relatively small quantities,

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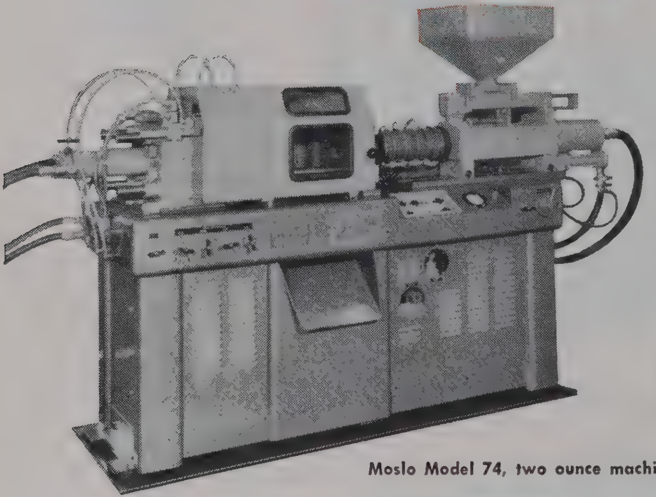
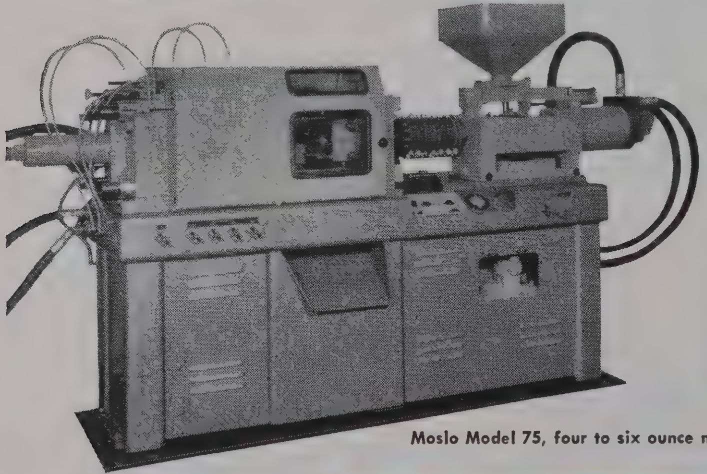
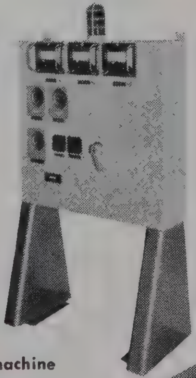
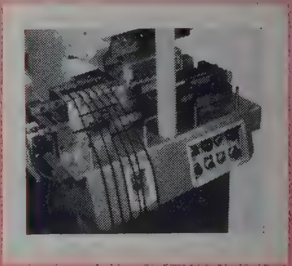


Moslo Model 74, two ounce machine

Moslo Model 75, four to six ounce machine



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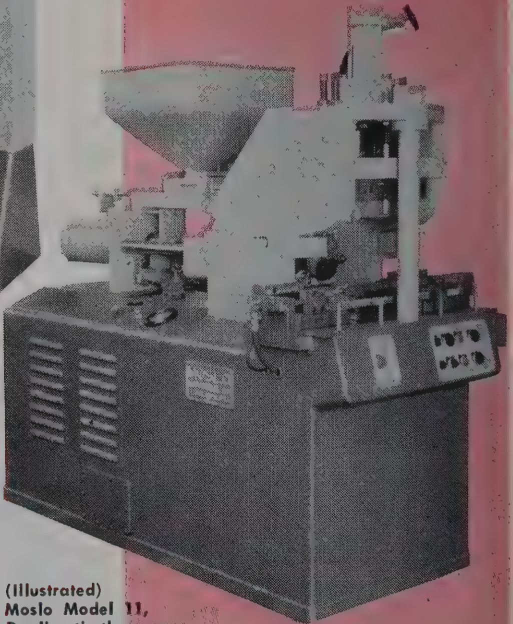

(Illustrated)
Moslo Model 11, Duplimatic three ounce machine. Moslo Model 12, four to six ounce Duplimatic also available.

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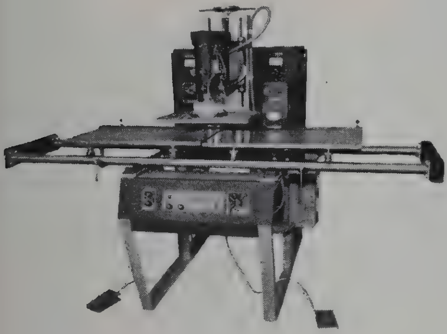
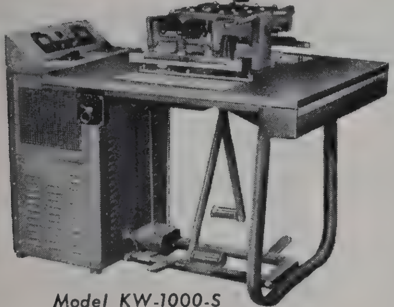


Model KS-2000-T
Max. output 2.5 Kw
Max. welding space 60 cm^2



Model KW-1000-S
Max. output 1.5 Kw
Max. welding space 30 cm^2

Inquiries on other models are also invited.

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he will usually find a single-stroke press best-suited to his needs, since such a press can accommodate a great variety of sizes of preforms, and, in addition, only one die per size is required, whereas for a rotary unit, up to 33 die sets per different size and shape would be needed. The molder who specializes in volume production of parts that require preforms of the same size and shape, such as a mass producer of buttons, collapsible tube caps, and closures of other types, will require a rotary preformer.

Material characteristics

Uniformity of density, thickness, and weight of preforms will depend partly upon the uniformity with which the material is fed into the preform die cavity. This, in turn, depends partly upon the granulation, flow properties, and bulk factor of the plastic material being fed.

Granulation: The granulation of general-purpose materials does not usually raise any feed problem. The occasional slight segregation of particles by size within the cavity is usually not serious enough to warrant the use of special devices to control it. But when the material is in the form of a fine powder or contains a high percentage of fines, air entrapment may create a problem. This can be alleviated to some extent by increasing the clearance between die and punch or applying a vacuum to the die cavity.

On the basis of bulk factor alone, a quick choice may be made between standard machines and those designed to handle high bulk factor materials. Most standard machines are intended to handle general-purpose materials with bulk factors as high as three to one. When equipped with special rotary feeding devices, they can be used with materials having bulk factors as high as six to one. However, when the bulk factor is higher than that, special presses must be used. On the other hand, the type of machine designed to handle high bulk factor materials would be uneconomical for use with ordinary materials because of the additional expense.

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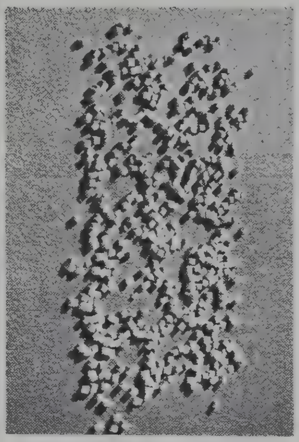
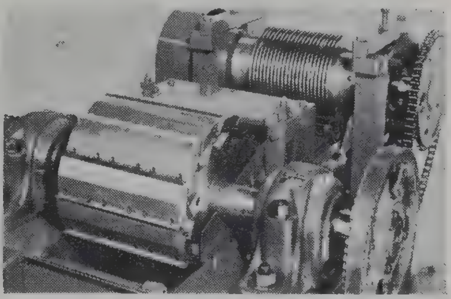


FROM SHEETS OR RODS



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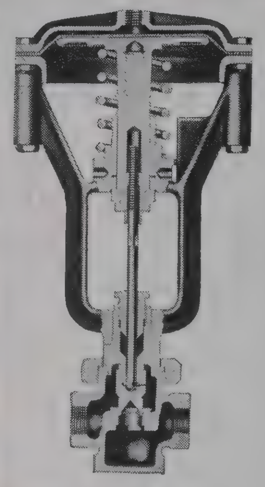
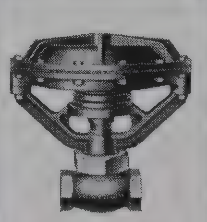
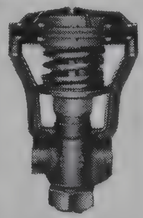


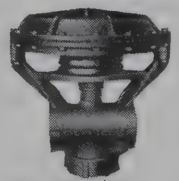
250 PSI, 2-WAY V-PORT MODULATING
controls temperature, pressure or flow, direct or reverse acting, ½—2 in. NPT



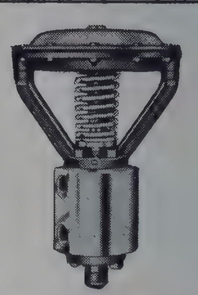
150 AND 300 PSI, DIRECT ACTING
globe body, top-guided stem, ¼—3 in. NPT



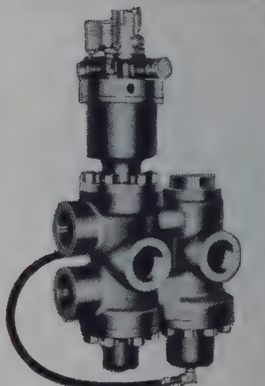
300 PSI, 3-WAY OR REVERSE ACTING
bridge yoke, triple-guided stem, ¼—3 in. NPT



150 PSI, 3-WAY OR REVERSE ACTING
compact design, bridge yoke, ¼—3 in. NPT



4,000 AND 6,000 PSI, 2 AND 3-WAY BALANCED
NC or NO, pressure above or below seats, ½—2 in. NPT



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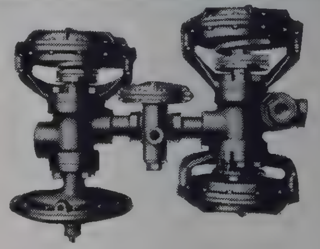

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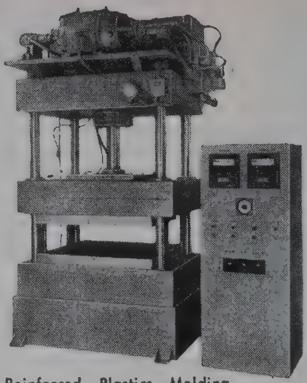
M & N Hydraulic Presses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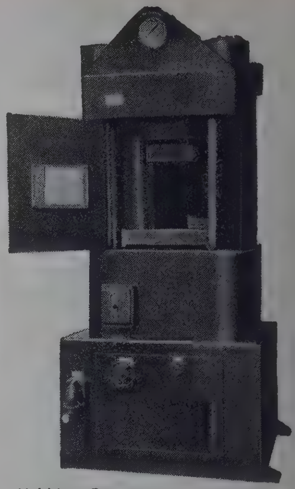
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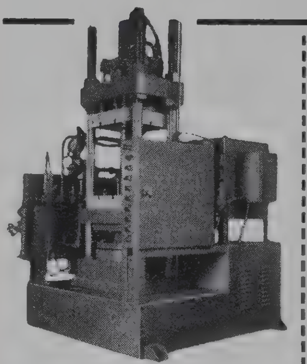
Capacities: 100 tons to 2000 tons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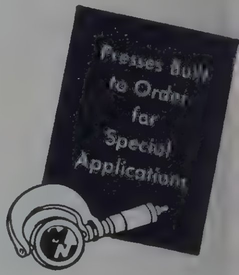
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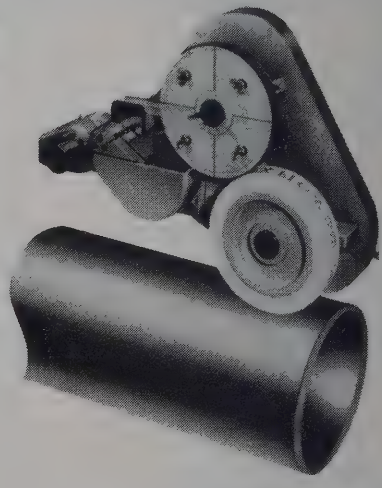

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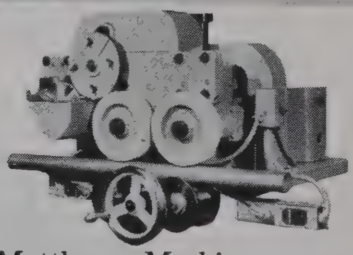

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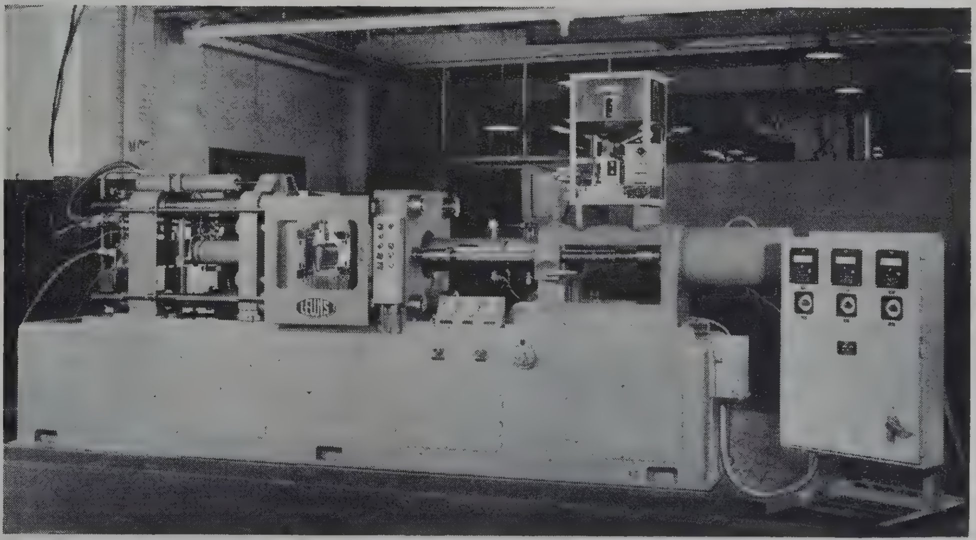
If you are planning or anticipating establishment of your own molding facility, why not discuss your requirements with Lewis before making a final decision.

The LEWIS 712-RM-24, for injection molding mechanical rubber goods, delivers up to 48 oz. of 1.25 elastomeric compound to the mold per single shot. Same basic machine is available for thermoplastic resins in varying shot sizes with conventional cylinder, pre-plasticizing cylinder or vinyl protected cylinder.



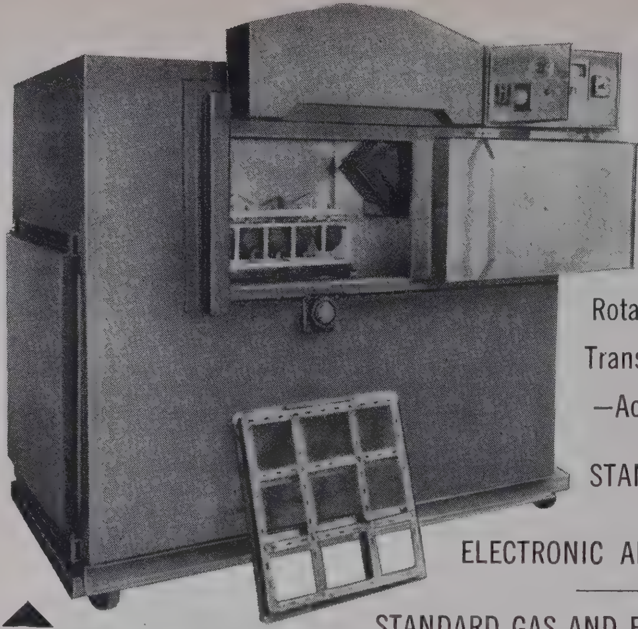
8601-LWM

LEWIS

THE LEWIS WELDING & ENGINEERING CORP.

104 NORTHFIELD ROAD • BEDFORD, OHIO

Designers • Engineers • Fabricators • Machinists



"PLASTICASTER" OVEN

Patent Applied For

DOUBLE ROTATION VINYL PLASTISOLS

COMPLETE EQUIPMENT

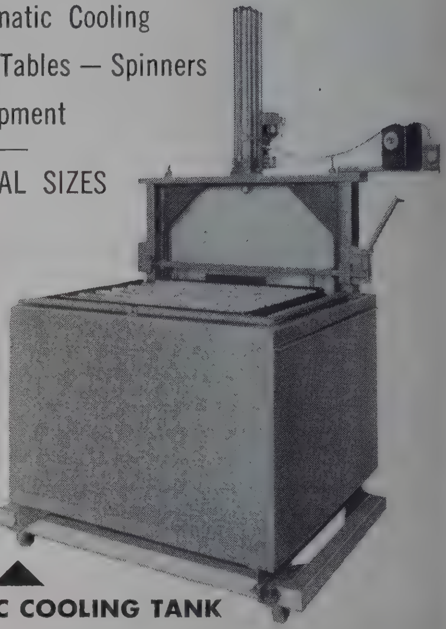
Rotation Ovens — Automatic Cooling
Transfer and Stripping Tables — Spinners
—Accurate Filling Equipment

STANDARD AND SPECIAL SIZES

ELECTRONIC AND TC CONTROLS

STANDARD GAS AND ELECTRIC HEATING

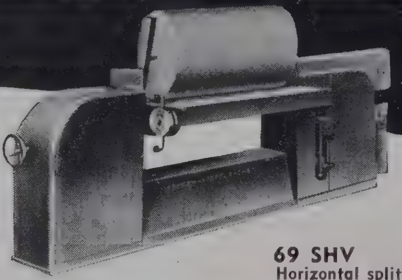
ENTIRELY NEW THERMAL LIQUID ROTATION PROCESS FOR LARGE AND SPECIAL PIECES



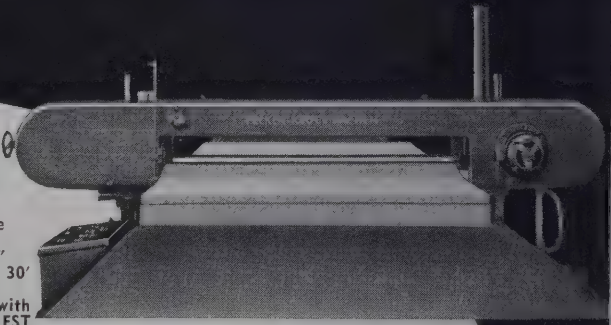
AUTOMATIC COOLING TANK

E. B. BLUE COMPANY
Connecticut Avenue, South Norwalk, Conn.
· **VINYL SLUSH MOLDING AND DIPPING**

Plastic Foam Cutting Machines



69 KR
For cutting endless foils from cylinders of plastic foam products and UNICREST. Maximum ϕ of cylinder 60″. Working width up to 80″



69 SHV
Horizontal splitting machine
30″ working height
Working widths 64″ and 80″
conveyor belt equipment of 30′ or table of 5 yds length.
Fully automatic. Equipped with bandsaw for sawing UNICREST

My *Representatives:* General Foam Corporation, 640 West 134th Street, New York 31, N. Y.

69 KP
For the manufacture of profiled plates of POLYURETHANE
Working width up to 80″
Feed 8.5—25 m/min.

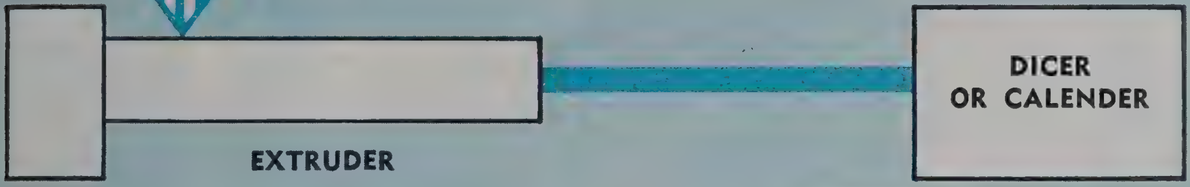
70 V
Vertical cutting machine
Working height 32″
Dimensions of table 80″ × 80″
Fully automatic if desired

FECKEN-KIRFEL MACHINE FACTORY
AACHEN-WESTERN-GERMANY / FOUNDED IN 1871

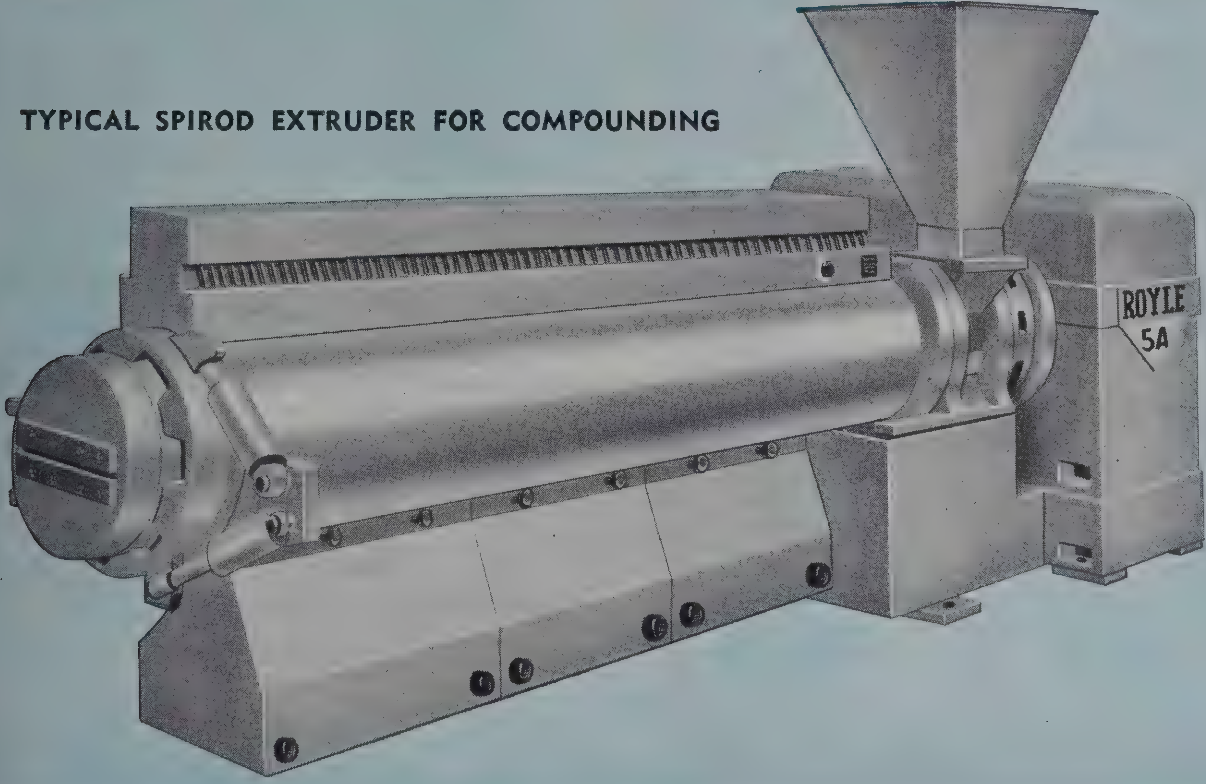
ROYLE SPIROD

Extruders

FOR PREPLASTICIZING AND RECLAIMING



TYPICAL SPIROD EXTRUDER FOR COMPOUNDING



Many compounders are now taking advantage of rugged **ROYLE SPIROD** extruders in their operations. Check these features:

- **Thrust bearings, with positive internal lubrication, designed for 10 years' minimum life.**
- **New dual head arrangement for reclaiming or coloring work; allows continuous operation while fixtures and screens are cleaned.**
- **New positive seal at stockscrew shoulder to prevent compound leakage with powder feeds.**
- **Evaporative cooling system particularly effective for melt-fed polyethylene processing extruder.**

JOHN ROYLE & SONS

ROYLE
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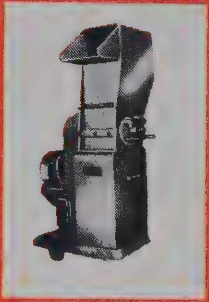
PIONEERED THE CONTINUOUS EXTRUSION PROCESS IN 1880

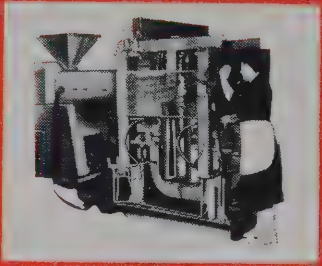
London, England	Home Office	Akron, Ohio	Downey, Cal.	Tokyo, Japan
James Day (Machinery) Ltd.	V. M. Hovey J. W. VanRiper	J. C. Clinefelter Co.	H. M. Royal, Inc.	Okura Trading Co., Ltd.
Hyde Park 2430 - 0456	SHerwood 2-8262	BLackstone 3-9222	TOpaz 1-0371	(56) 2130 - 2149

DE MATTIA 4/6, 12/16 OZ.
Injection Molding Machines

ACME Refrigeration Systems for Injection Molding Machines



ACME By-The-Machine Granulators in 1½, 2, 3 H.P.

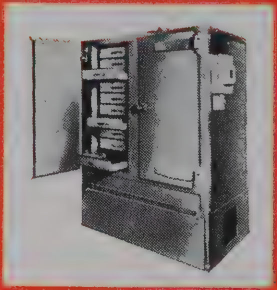


BOSTON Double Head Bottle Blowing Machines
2 Molds Size: 36″ x 14″

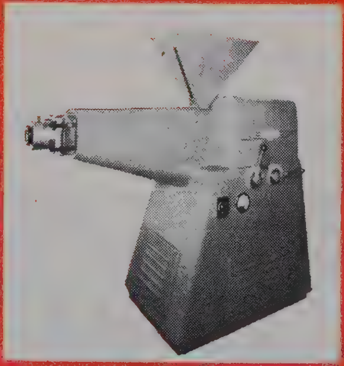
ACME

Plastics Machinery

ACME Double End Blenders ¼ H.P.



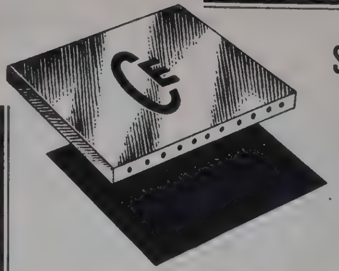
ACME Ovens 5 to 20 Draws



NEGRI BOSSI Extruders with American Controls

ACME MACHINERY & MFG. CO., INC.

20 South Broadway	102 Grove Street	5222 W. North Ave.
YONKERS, N. Y.	WORCESTER, MASS.	CHICAGO 39, ILL.
YOnkers 5-0900	PLeasant 7-7747	TUxedo 9-1328



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or HEATING and COOLING

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SURFACE GRINDING

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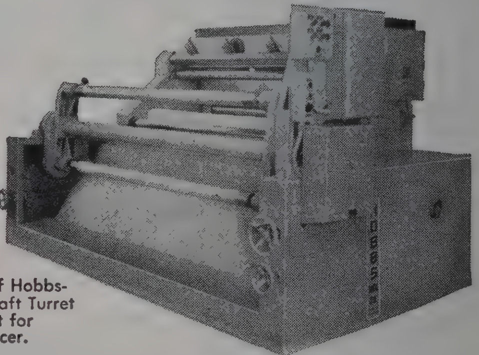
UP TO 84″ x 144″

CUSTOM ENGINEERING CO.

P. O. Box 1343 • Phone GLendale 6-7011 • Erie, Pa.

Winding AFTER EXTRUDING AS ENGINEERED BY HOBBS-ALQUIST



Side view of Hobbs-Alquist 2 Shaft Turret Winder built for resins producer.

Here is a graphic application of how *complete* engineered winding after extruding can be when engineered by Hobbs-Alquist. At the plant of a leading resins producer a Hobbs-Alquist Winder installation is engineered to handle plastic film heat treating and slitting, then turret wind the material and take care of trim disposal . . . all tied into a previous process to make continuous operation a swift, sure, economical fact.

Send for the Brochure —
Hobbs-Alquist Engineered Winding

HOBBS MANUFACTURING CO.
551 Salisbury St., Worcester 5, Mass.

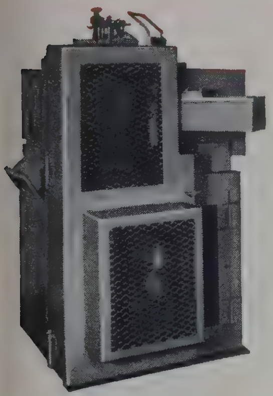
Representatives in Irvington, N. J.; Chicago; Cleveland; Greenville; Louisville; Toronto.

WINDERS
HAND & POWER SHEARS
SLITTERS
DIE PRESSES
AUTO. CUTTERS

CUMBERLAND

Plastics Size-Reduction Machinery

Cumberland "Stair-Step" Dicing Machines



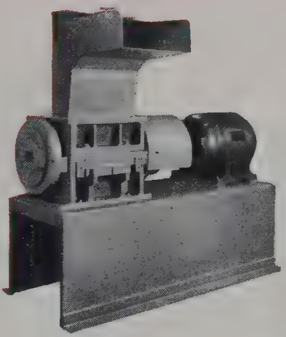
For dicing the *full range* of thermoplastic materials.

Cubes 1/16" to 1" produced from plastic sheet or ribbon stock. Pellet sizes altered merely by changing knives. Cubing is done in one severing operation with rotor knives cutting against one bed knife.

All surfaces contacting plastic materials are of corrosion-resistant metals.

Two sizes of machine available to handle sheets up to 7" and 14" in width.

Cumberland Model 20 Granulator

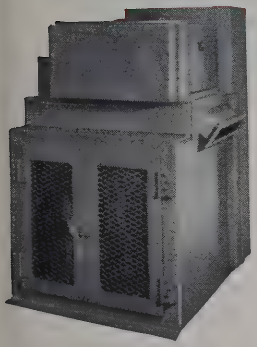


This heavy-duty steel machine with 9" x 20" or 12¾" x 20" throat openings is suited for granulating tough plastic materials in the form of slabs, bleeder scrap, cylinder purgings, heavy cross-sectional parts, etc.

Frame and cutting chamber are of thick weldments with deep welds. Rotor and seal rings are heat treated and ground all over to provide tough, undamageable parts. Hardened surfaces preserve new appearance.

Machines resist wreckage. All inner surfaces are ground smooth to provide ease of cleaning.

Cumberland Pelletizing Machines



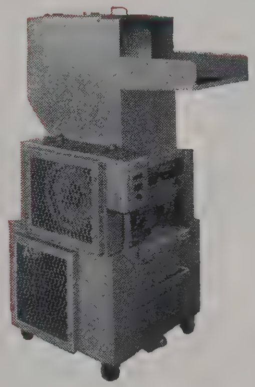
A versatile machine designed for use as a pelletizer, chopper or dicer.

As a pelletizing machine it cuts multiple extruded strands of plastic material into cylindrically shaped pieces or cubes for use in molding or extrusion machines.

As a notched-knife or ratchet-tooth dicing machine it produces rectangular pellets from milled sheets or extruded ribbons. It is less expensive, although less universal, than the "Stair-Step" Dicer.

As a chopping machine it efficiently cuts rubber and vinyl slabs into small pieces.

Five New Cumberland Large Throat Granulating Machines



Large throat openings—7" x 10", 8½" x 12", 8½" x 16", 12" x 16", 12" x 20"—designed for use beside the press or for central granulating machines.

New knife design and slow rotor rpm provide better granulation, and at the same time yield quiet operation. Clean cutting is assured throughout the complete range of thermoplastic materials from softest polyethylene and vinyls to hard and tough nylon, Cycolac and Kralastic.

Quality construction, rugged as all Cumberland machines, is entirely of steel weldments. Advanced design leaves all working parts readily accessible for cleaning and adjustment of knives.

Minimum floor space is required — for all models.

OTHER GRANULATING MACHINES

CUMBERLAND MODELS 0, ½, 1½—V-Belt or Direct Coupled

This series of machines is of the overhung rotor type. For laboratory use, beside the injection molding press or central granulating. Efficient cutting chamber combines compactness with high capacity.

Throat openings: Model 0—3¾" x 5½", 5¼" x 5¾"; Model ½—4" x 8", 6½" x 7¾"; Model 1½—5" x 12", 8" x 11"

CUMBERLAND MODEL 18—Direct Coupled

For central granulating use.

Throat openings: 5" x 18", 8" x 18"

CUMBERLAND MODEL 37—Extra large throat openings for bulky reclaim with high capacity.

Throat openings: 13¼" x 37½", 15¼" x 37½", 15¼" x 50", 24" x 50", 24" x 60"

CUMBERLAND MODEL 43—

Extra heavy duty granulator with 13" x 43½" throat opening. Made entirely of heavy steel weldments. Easily handles heavy cross sections, purgings, cast plastic ingots of the toughest materials.

Motor: 75 HP through 200 HP.

Cumberland
ENGINEERING COMPANY, INC.

DEPT. T, BOX 216, PROVIDENCE 1, RHODE ISLAND

Direct factory engineering assistance available throughout North America from sales offices in Providence, New York, Cleveland, Chicago and Los Angeles.

FOREIGN LICENSEE—**Burtonwood Engineering Company, Ltd., Burtonwood, Warrington, Lancashire, England—Sole Manufacturers and Distributors outside North and South America.**

294-9

From die to complete post extrusion equipment—

ROBBINS DIES:

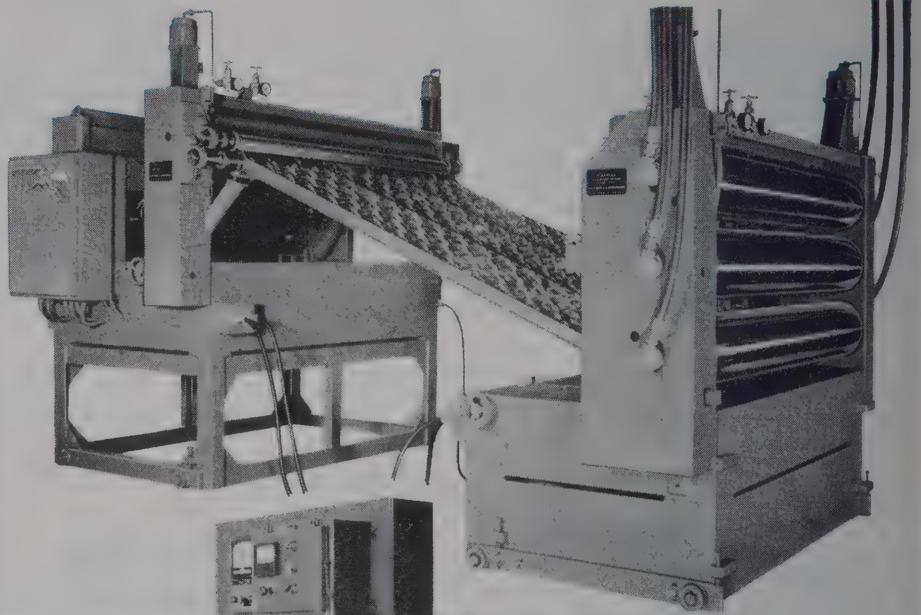
Sheet
Flat Film
Blown Film
Pipe—rigid and flexible
Tubing
Monofilament
Strands

All dies complete with adapter to fit your extruder

ROBBINS POST EXTRUSION EQUIPMENT:

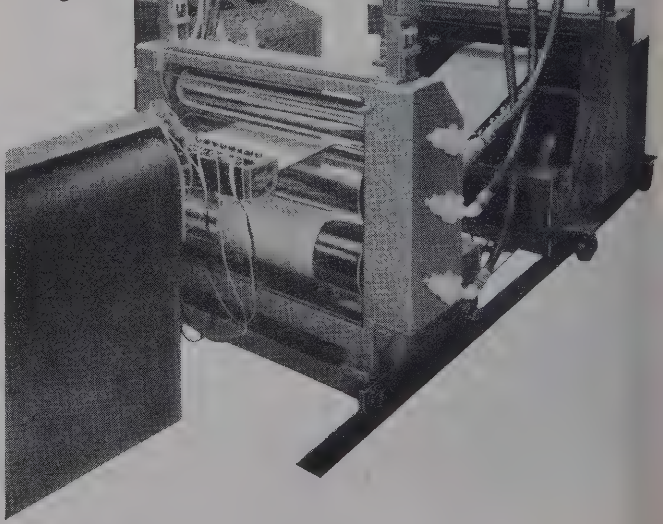
Conveyors
Refrigerated Water Tanks
Shears, Trimmers
Capstans
Sheet and Film
Haul Offs & Wind Ups
Sheet Polishers, Stackers
Pipe Coilers, Pull-Offs
Heat Exchangers
Cut-Off Saws
Forming Tanks and Racks
Control Cabinets

Complete "packaged" installations for flat film and sheet; also blown film, monofilament processing, pipe and profiles



Robbins extra large sheet processing unit for sheets up to 75" wide—a wide range of sheet thicknesses. All three chrome rolls 12" diameter.

Monofilament die. Five roll stretching unit and Godet unit. Tanks and winders not shown are also available for your special needs.



Robbins customer material evaluation and processing laboratory. Consult us on your development and research problems.

CHOOSE ROBBINS

Multiple Blown Film dies and haul-off, including blowers, air rings, wind-ups, etc., for heavy to light gauge film.

Artist's drawing illustrates three blown tube production units from one extruder.

Robbins

ROBBINS PLASTIC MACHINERY CORP.

Subsidiary of Lynch Corp., Anderson, Ind., U.S.A.

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ROBBINS REPRESENTATIVES: Machinery Sales Co., Los Angeles 58, Calif.; Wilmod Co. Rubber Division, Toronto 10, Canada; C. Itoh & Co. Ltd., Tokyo and Osaka, Japan

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the complete
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INJECTI
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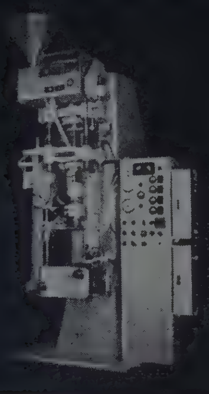
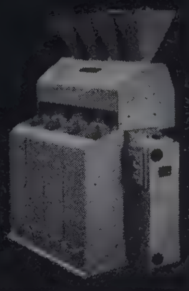
BLOW MOLD
EXTRUSI



Blow Molding Machines
with piston and screw feed
up to 215 pts



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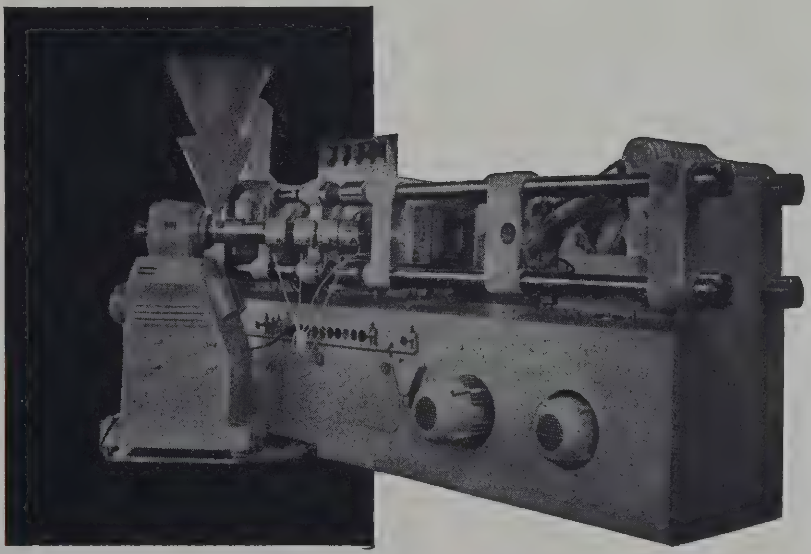
Compression and Transfer Molding Machines
up to 300 tons capacity

Extruders and complete Automatic Plants
(with screw diameters
1¼" 1¾" 2½" 3½" and 6" approx)

INJECTION MOLDING MACHINES

from 1/10 oz. upwards

with
SCREW PLASTICIZING UNIT
from 1 – 350 OZS



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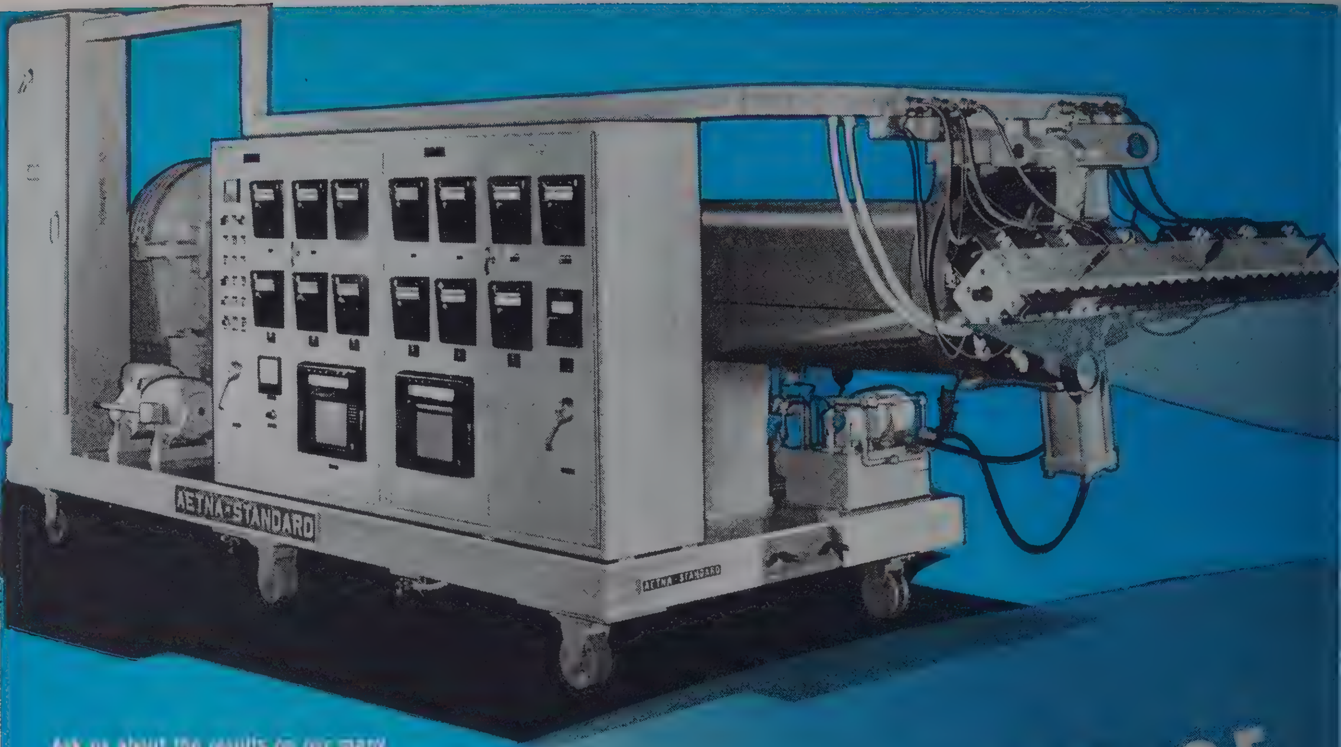
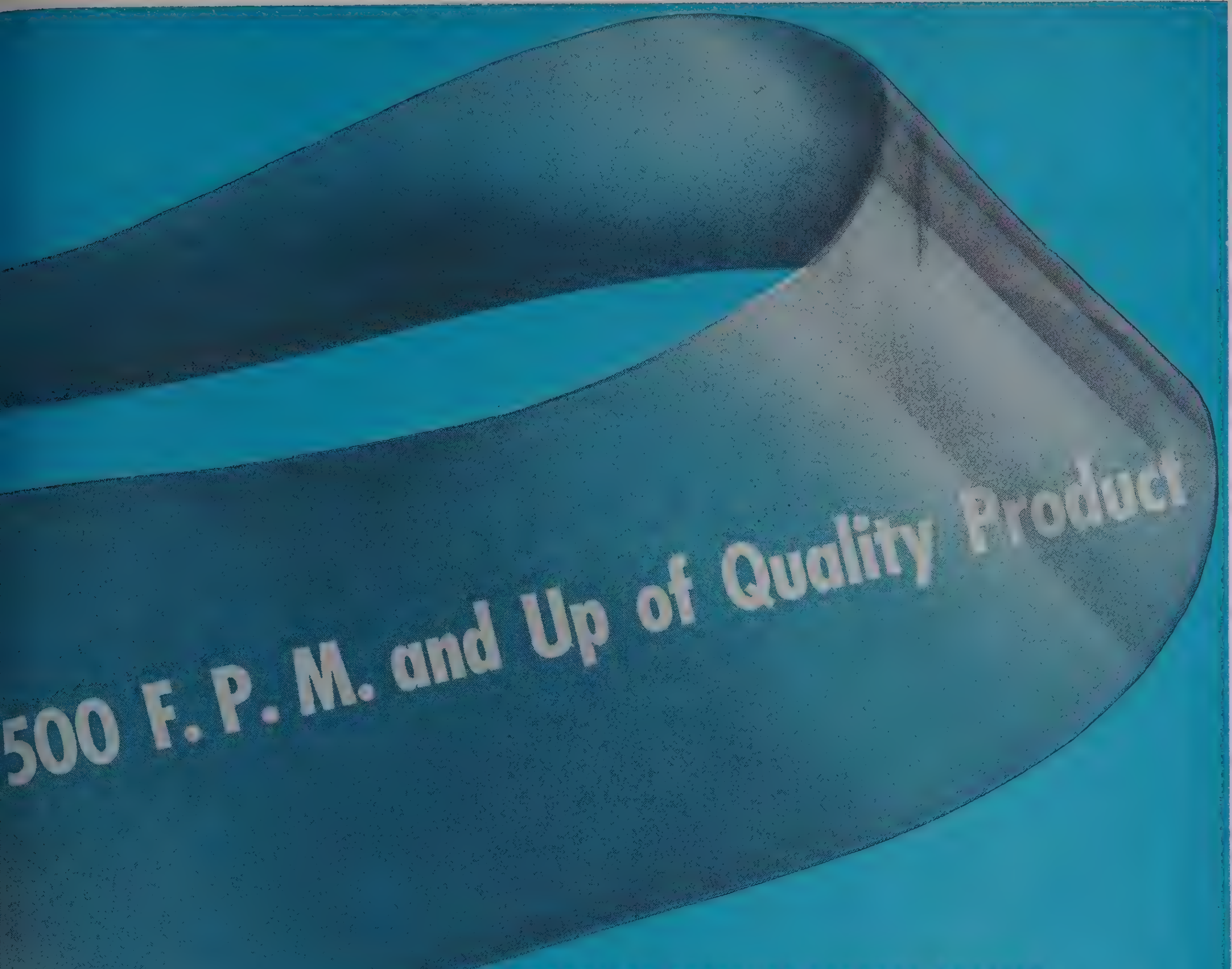


Ask us about the results on our many induction heated extruders in use.

HIGH SPEED PRODUCTION OF UNIFORM GAUGE OVERWRAP FILM now available using Aetna-Standard Induction Heated Extruders and Dies

INDUCTION HEATED DIES

Include all the features required for uniform gauge control: induction heating of the insulated body provides uniform temperature throughout the die; a unique design of leak-proof deckle equipment minimizes trim width; simple land adjustment, in combination with multi-zone temperature controls, minimizes run-in time.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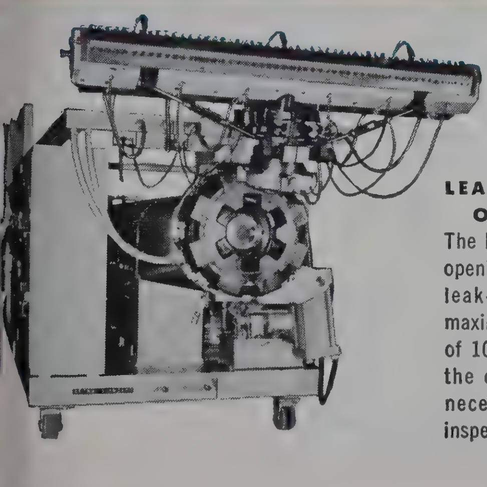
CONTROLLED PRESSURE ASSURES QUALITY... The controlled pressure plasticizing action of the screw can be maintained independently of die pressure or screen pack conditions.

HIGH SPEED SCREWS accurately designed for adiabatic operation assure the ultimate in output rates.

INDUCTION HEATING SYSTEMS, including automatic water-cooling equipment, provide "on the button" temperature control.

UNITIZED CONSTRUCTION... Just set it on the rails and connect the power supply.

COMPLETE INSTRUMENTATION... Recording of speed, melt temperatures, melt pressures, provides a complete record of performance.



LEAK-PROOF QUICK OPENING HEAD

The breech-lock-type, quick opening die adapter assures leak-proof sealing at the maximum design pressures of 10,000 p. s. i., plus all the quick opening features necessary for screen pack inspection.

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Fast Economical MOULDING

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NEW SERIES II

High cycling speeds (1200 an hour dry) give optimum output with moulds having fewer cavities which are quicker to make and less costly. The patented internally fluted cylinder gives unusually rapid plasticising. Fully automatic—one operator can supervise a battery of machines.

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STANDARD MODEL
capacity 30 grammes

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capacity 22 grammes

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INJECTION MOULDING MACHINES

For short runs and pilot production.

POWER OPERATED MODEL
15 grammes capacity

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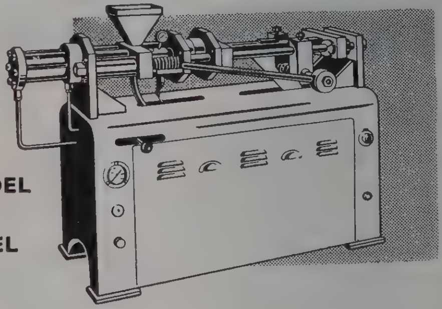
10 grammes capacity



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MICO PORTABLE PANTOGRAPH ENGRAVERS

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The Electrode Steam Boiler
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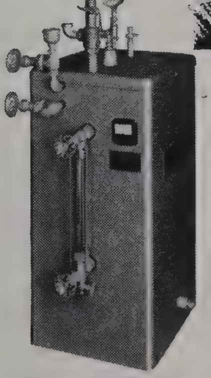

Compact, precision-built Series "R" units plug in on 115 or 230-volt circuits—steam at the flick of a switch. ASME Power Code. Precise, non-fluctuating pressure-temperature control. Ideal for R&D laboratories, pilot plants and small plastics press production! Also effective for high-pressure steam-jet cleaning... accessory kits available.

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The Weak Link
IN PLASTIC PRODUCTION

IS *Still* HEAT CONTROL

The plastic and plastic machine manufacturers have made available for processing plants the materials and equipment to substantially increase production and widen their prospective market.

A survey of hundreds of plants, however, indicates that this productive potential is not being utilized to its fullest extent, primarily due to two important factors.

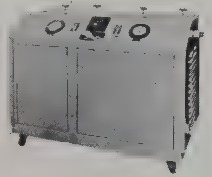
1. The inadequate or inefficient removal of process heat.
2. The increasing restrictive use **and cost** of process water.

Both of these factors materially reduce the net return on material, machine and labor investment.

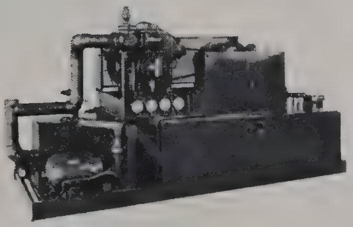
This source of lost profit can be salvaged regardless of the equipment and process involved, provided the same specialized engineering know-how is employed on heat control, as was used in the development of modern materials and processing machines.

Results have proved that proper temperature control and water usage can increase plant efficiency from 10% to 30%—decrease water cost 95%.

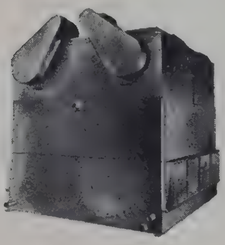
The Mayer organization specializes in the removal of plastic process heat and will be pleased to discuss with you the possibility of increased production, quality control and lower operating cost in your plant.



Junior Chil-er Recirculating Units For Individual Machines or Process
Temperature
—10°F. to +60°F.



W-Chil-er Recirculating Units
For Group or Plant Installation
Temperature —150°F. to +60°F.



Water Economizers for Recirculation of Process Water
Water Temperature +85°F.

For further information or a personal visit

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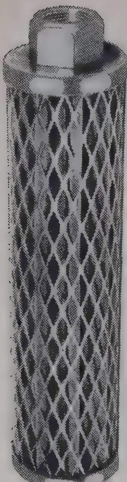


Tandem Synclinal SUMP TYPE

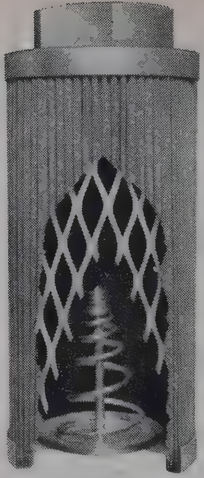
CAPACITIES: 10—16—20—40—60—100—150 and 200 G.P.M.

PIPE SIZES: ¾″—1″—1¼″—1½″—2″—2½″ and 3″.

CONNECTIONS: Coupling—Male Nipple.

BY-PASS VALVE: Not available.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.



Bonded SUMP TYPE

CAPACITIES: 10—20—30—50 and 75 G.P.M.

PIPE SIZES: 1″—1¼″—1½″—2″—and 2½″.

CONNECTIONS: Coupling—"O" Ring—Male Nipple.

BY-PASS VALVE: Available with or without By-Pass Valve.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants and all types of Fire-resistant Hydraulic Fluids.

MARVEL

SYNCLINAL FILTERS

FOR DEPENDABLE PROTECTION on all Hydraulic and other low pressure circulating systems

MARVEL FILTERS are designed to give more ACTIVE filtering area—MORE dependable protection—MORE productive operation before filter cleaning is necessary. *They meet J. I. C. Standards.*

FILTERING MEDIA in all Marvel Filters is Monel wire cloth and available in mesh sizes of 30-40-50-60-80-100-150 and 200 to meet your degree of filtration requirement.

EASY TO CLEAN—All Marvel Filters are easy to clean. Line type units operate in any position and may be serviced without disturbing pipe connections.

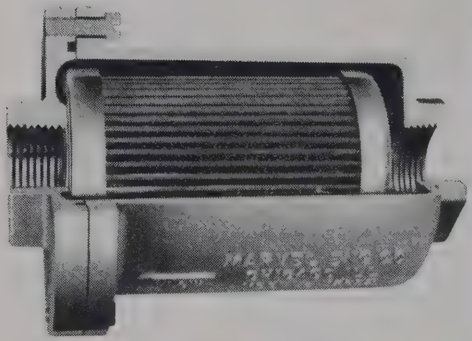
OVER 900 Original Equipment Manufacturers install Marvel Filters as Standard Equipment.

IMMEDIATE DELIVERY

For further information on a specific type or size filter—Write—wire or phone

MARVEL ENGINEERING COMPANY

7227 N. Hamlin Ave., Chicago 45, Illinois • Phone: JUniper 8-6023



IN-LINE FILTER

CAPACITIES: Up to 60 G.P.M.

PIPE SIZES: ¾″—1″—1¼″ and 1½″ (at both inlet and outlet).

BY-PASS VALVE: Available with or without By-Pass Valve.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants and all types of Fire-resistant Hydraulic Fluids.

Synclinal SUMP TYPE

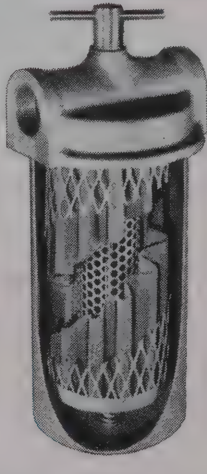
CAPACITIES: 5—8—10—20—30—50—75 and 100 G.P.M.

PIPE SIZES: ¾″—1″—1¼″—1½″—2″—2½″ and 3″.

CONNECTIONS: Coupling—Male Nipple.

BY-PASS VALVE: Not Available.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.



Synclinal LINE TYPE

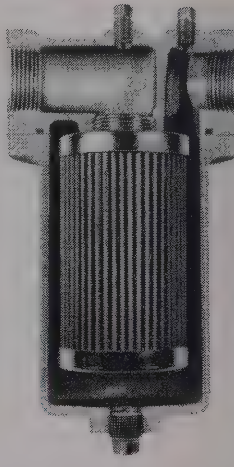
CAPACITIES: 5—8—10—20—30—50—75 and 100 G.P.M.

PIPE SIZES: ¾″—1″—1¼″—1½″—2″—2½″ and 3″.

BY-PASS VALVE: Not available.

OPERATING PRESSURES: Up to 80 p.s.i.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.



Bonded LINE TYPE

CAPACITIES: 10—20—30—50 and 75 G.P.M

PIPE SIZES: 1″—1¼″—1½″—2″ and 2½″.

BY-PASS VALVE: Available with or without

OPERATING PRESSURE: Up to 250 p.s.i.

OPERATING TEMPERATURES up to 300° F

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistan Hydraulic Fluids.

TOMORROW'S ENGINEERING TODAY . . .

NRM

Thermoplastics

EXTRUDERS and EQUIPMENT

NRM 15 IN. EXTRUDER WITH AUTOMATIC DIE HEAD CLAMP

Give you the benefit of . . .

- MORE EXTRUSION POUNDS PER HOUR
- HIGHER QUALITY EXTRUSIONS
- LOWER MAINTENANCE COST
- LONGER EXTRUDER LIFE

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MACHINERY COMPANY

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47 West Exchange St., Akron 8, Ohio
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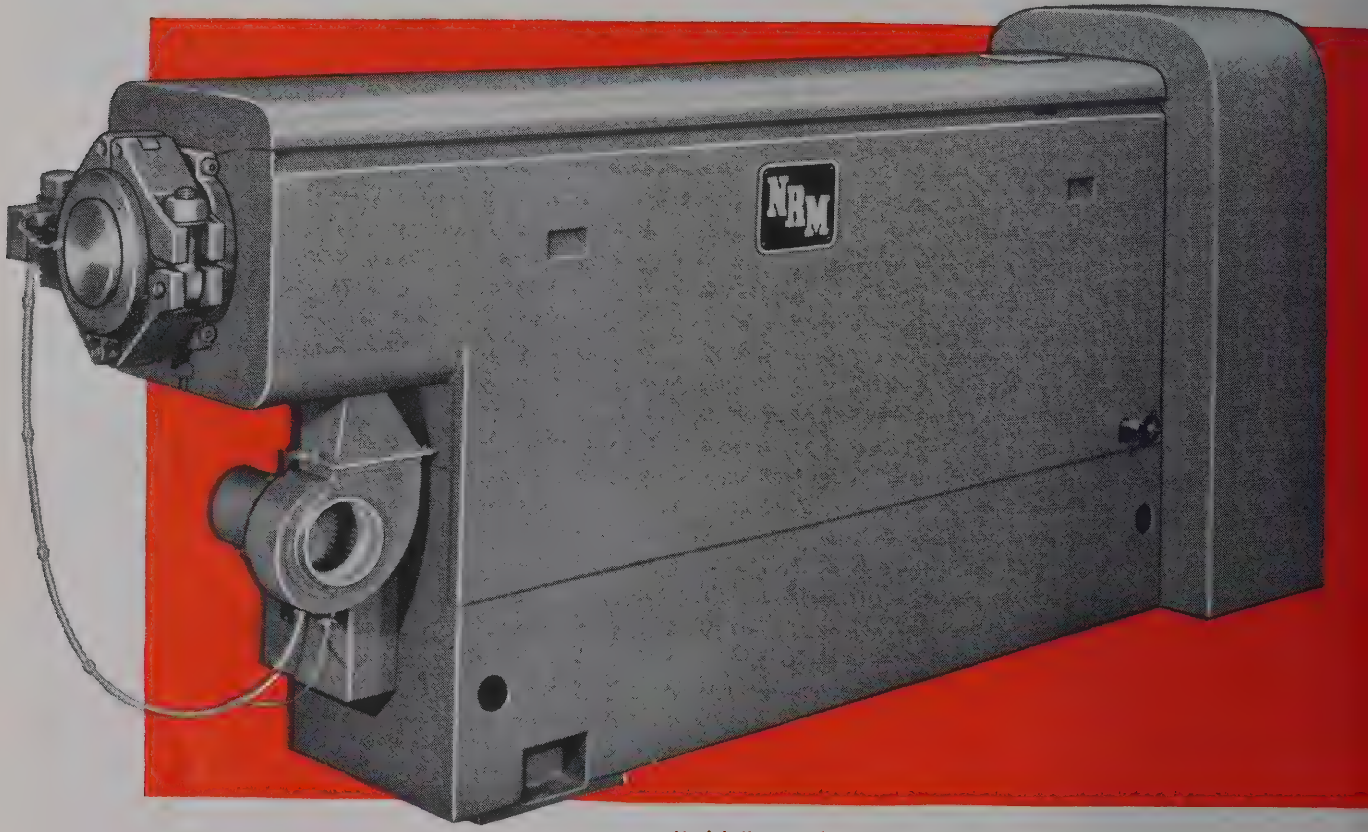
EXPORT: Omni Products Corporation,
460 Park Ave., So. New York, N. Y.

NRM

MORE POUNDS PER DOLLAR ...MORE POUNDS PER HOUR



Model illustrated—NRM 4½ in. Extruder with standard control cabinet.

• **HIGH POUNDS/HOUR RATES** — NRM Extruders produce more high quality, close tolerance extrusions, with less waste than other makes. NRM Extruders are the most exactly manufactured machines, with closer tolerances, using the finest quality components. They feature highly efficient screw design, backed by NRM's exclusive background of more than 30 years of extruder design and manufacturing experience.

• **MINIMUM DOWNTIME** — NRM Extruders will run longer, with less attention than any others because of advanced design, careful manufacturing and heavy-duty construction. NRM's latest engineering advances always are incorporated into its standard line of machines — not offered as cost-increasing optional extras.

• **LONG, PROFITABLE WORKING LIFE** — NRM Extruders are designed and built in NRM's own shops. This affords closest control of quality and performance from the designer's drawing board to installation in your plant. What's more, NRM is working constantly with its customers, major materials suppliers, and in its own experimental laboratories, to develop more efficient screw designs and to perfect extruding techniques for new materials. That's why NRM Extruders are famous for *sustained* high productive operation, faster capital return and many years of profitable operation.

Both in the machine and in product produced, you get more pounds per dollar with NRM

WRITE OR PHONE NRM

Get full engineering information . . . arrange for demonstrations. Our recently expanded and improved research laboratory facilities are available to assist in testing your compounds, or in determining the right type and size extruders to do your work most efficiently. Remember, NRM stands ready to work with you and your materials suppliers to boost your production and your profits. Before buying any extrusion equipment, look into the NRM line . . . compare NRM with other makes, feature for feature, on standard machines . . . consider the research, engineering, development and *company service* that stands behind NRM. It's the name in extruders that assures highest production, finest quality extrusions, less operating cost, and more profit.

NRM makes the only complete standard line of extruders from 1" to 15"—including standard package units, complete with all accessories

RIGID AND ELASTOMERIC SHEETS • Complete production unit from extruder to automatic stacker or wind-up for elastomeric materials. Extruder is furnished either vented or unvented, sized to meet production requirements. Electric control cabinets have all instruments and controls for operating the complete installation. Dies are specially engineered for such materials as high impact polystyrene, high density polyethylene, acrylics, cellulose acetate, butyrate, and both rigid and elastomeric PVC. Standard gauges conservatively from .040 to .375 . . . widths up to 72". Larger widths and other gauges are available on request. Positive gauge control is provided by two-way adjustment of restrictor bar and die blade.

PLASTIC PIPE • NRM offers standard production installations for flexible and rigid pipe up to 8" in dia., from PVC, high and low density polyethylene, Kralastic, butyrate and others. Dies are available for a complete range of sizes, in either straight-out or offset types. Built-in adjustable flow rings assure positive tolerance control. Streamlined interiors provide "free flow" and assure long wear life. Dies can be furnished with built-in valve for adjusting extrusion pressure.

BLOWN FILM • Complete production units available for extruded diameters up to 36", larger on request. Die lips are adjustable for concentricity, and hardened and ground for long wear life. Highly polished chrome interiors prevent chance of die marks on film. Positive film gauge control is provided by full diameter, independently adjustable equalizer rings. Dies are furnished with all necessary heaters and controls.

CAST FILM • Complete production installations for standard widths up to 84". Wider widths on request.

NRM ACCESSORIES • Include conveyors, cooling tanks, pipe hauloffs, etc. Contact us for full details.

Whether you need 6 pounds per hour of plastics production from a single machine, or 6,000 . . . there's an NRM to produce it economically, with plenty of capacity and versatility to spare. Sizes range from 1" laboratory and light production models to big 15" high capacity extruders with automatic die head clamps. Typical performance data for various sizes is given in the following table.

Code

EH—Electrically heated (resistance)
IH—Induction heated
SH—Steam heated
(Oil and steam heated extruders available in all sizes.)

NRM PLASTICS EXTRUDERS

MODEL NUMBER	50-11	1½"-55 EH	2½" EH or IH	3½" EH or IH	4½" EH or IH	6" EH	8" EH	10" EH	15" SH
Nominal screw dia., in.	1"	1½"	2½"	3½"	4½"	6"	8"	10"	15"
L/D ratios available	12:1, 17:1*	16:1, 20:1, 24:1*	16:1, 20:1, 24:1*	16:1, 20:1, 24:1*	16:1, 20:1 24:1*	16:1, 20:1, 24:1	16:1, 20:1, 24:1	16:1, 20:1, 24:1	16:1, 20:1, 24:1
Type of transmission	Gear & Belt	Chain type	Helical				Herringbone		
Motor H. P.	¾	5	25	50	100	150	250	400	800
Screw speed range, rpm	21.3-58.7 48-132	125 top	120 top	100 top	90 top	80 top	70 top	60 top	60 top
Max. output of polyethylene (Dens. —0.92; MI-2), lb./hr.	10 lb./hr. nominal	50 lb./hr.	150 lb./hr.	300 lb./hr.	550 lb./hr.	750 lb./hr.	1500 lb./hr.	3000 lb./hr.	6000 lb./hr.
Cooling system (cylinder)	Ambient Atmosphere	Air or fluid							Fluid
Safe operating head pressure p.s.i.	5,000 p.s.i.	10,000 p.s.i.	10,000 p.s.i.	10,000 p.s.i.	10,000 p.s.i.	10,000 p.s.i.	10,000 p.s.i.	10,000 p.s.i.	10,000 p.s.i.
% of rated motor H. P. delivered to screw: at full speed	80%	95%	95%	97%					
at ⅓ full speed	27%	32%	32%	32%					
Materials for construction of barrel	1-piece steel with integral Xaloy 306 lining								Alloy steel casting with Xaloy 306 lining
Efficiency of transmission, %	85%	95%	96%	97%			95%		
Temperature controls, type	Proportioning								Steam system
Venting and devolatilizing features available?	Yes								No
Type of Heater	Band	Cast-In	Cast-In or Induction			Cast-In			Steam
Number of zones	2		4		5		6	7	8
Approx. heat-up time to 350 degrees F.	½ hr.	¾ hr.	Resist. htr.—1 hr. Ind. htr.—½ hr.		Resist. htr. 1 hr. Ind. htr. ¾ hr.	Resist. htr.—1 hr.	1½ hrs.		4 hrs.
Max. total heater Wattage, KW	1.2	5.1	13.75	25.8	38.5	62	100	150	Steam

*Available in vented type

NRM

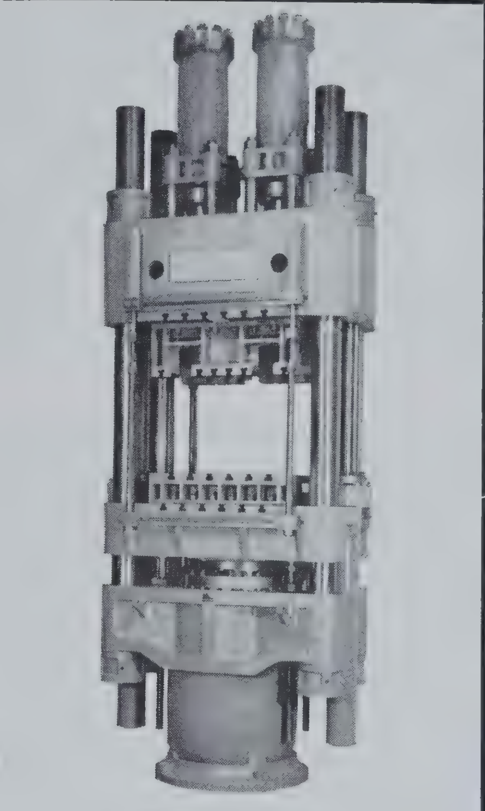
. . . the extruder that offers more pounds per dollar

2134-A

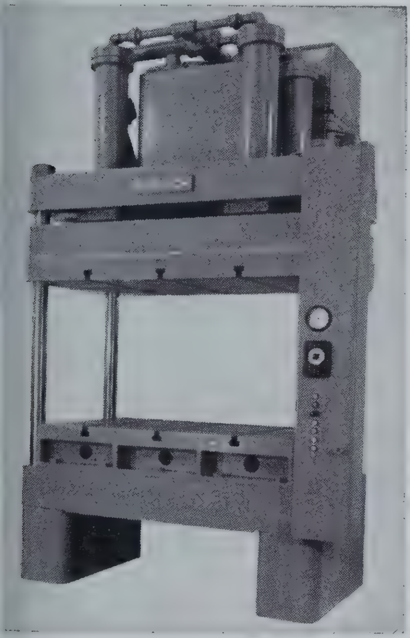
french HYDRAULIC PRESSES

for Compression Molding Transfer Molding Laminating

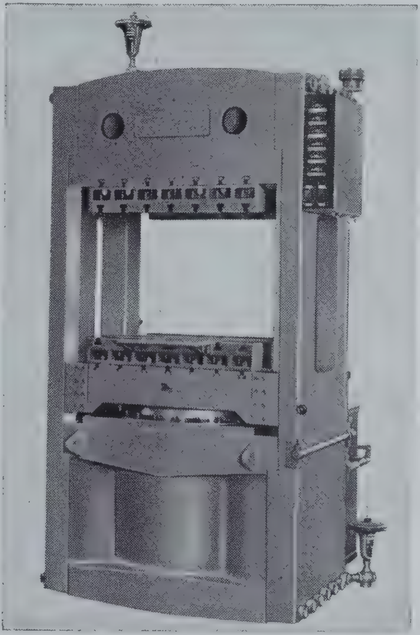
French builds a complete line of standard and custom made oil or water hydraulic presses in sizes up to 4000 tons. Available in either side plate or column type construction, self-contained or for use with accumulators, these presses are supplied with semi automatic controls. Backed by many years of hydraulic engineering and manufacturing experience, French presses are designed to meet specific job requirements. Incorporated in the basic design are many outstanding and patented features that have earned them an enviable record for high quality production efficiency and low cost, maintenance-free, operation.



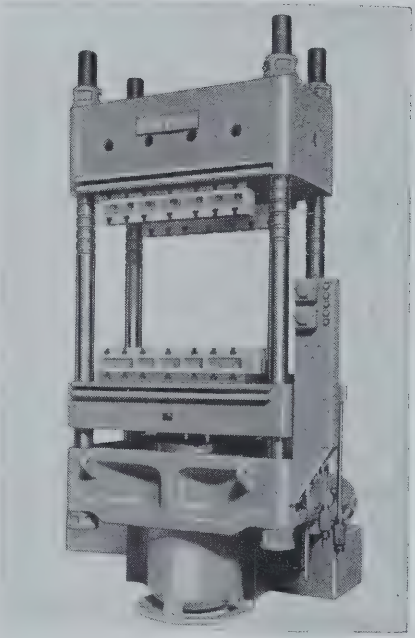
519 ton Transfer Molding Press; 30″ Stroke; 38 to 60 Adj. Daylight; 34″ x 32½″ Pressing Surface; 3000 P.S.I. Working Pressure



200 ton press; 36″ Stroke; 54″ Daylight; 72″ x 48″ Pressing Surface; 2000 P.S.I. Working Pressure



800 ton press; 24″ Diameter ram; 16″ Stroke; 41″ Daylight; 48″ x 36″ Pressing Surface



300 ton Compression Press; 19½″ Diameter ram; 2000 P.S.I. Working Pressure; 24″ Stroke; 28″ to 52″ adj. Daylight; 48″ x 31″ Pressing Surface

Illustrated are only a few of the many types of presses designed and built by French. For more complete information and illustrated bulletins on French Hydraulic Presses, write us today!

french

HYDRAULIC PRESS DIVISION

REPRESENTATIVES ACROSS THE NATION:
Boston — New York — Cleveland
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THE FRENCH OIL MILL MACHINERY CO.
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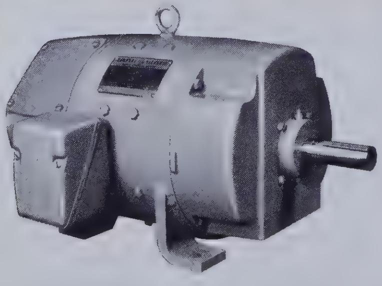
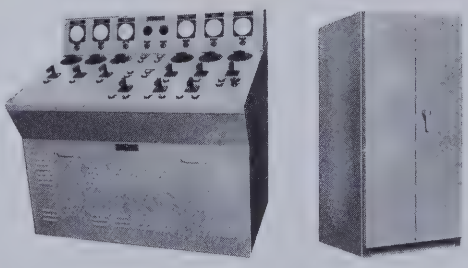
MODERNIZE FOR PROFITS

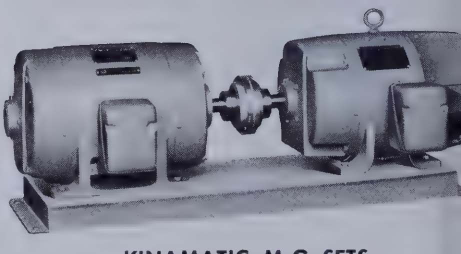
SELECT YOUR DRIVE FROM GENERAL ELECTRIC'S COMPLET



KINAMATIC DRIVE MOTORS



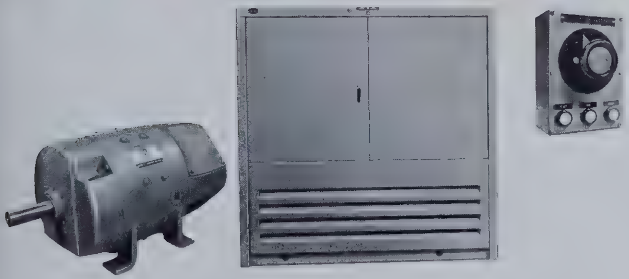
CUSTOM-BUILT CONTROLS



KINAMATIC M-G SETS

You can combat the cost/profit squeeze with a planned program of drive modernization...modernization that provides greater machine flexibility, better quality control, higher output from your calender and extruder. Start your program now. Apply the modern, high performance advantages of General Electric direct-current adjustable-speed drives...drives that provide the fast stops, wide speed range and precision control vital to modern automatic machines. To learn more about the modern capabilities of Kinamatic® motors, Speed Variators and custom-built controls, call your nearby G-E Apparatus Office, or mail the coupon below for a helpful Drive Selection Kit.

INE OF D-C EQUIPMENT



SPEED VARIATOR PACKAGED DRIVES

To: Section 822-1, General Electric Company, Direct Current Motor and Generator Department, 3001 East Lake Road, Erie, Pennsylvania

Please send me the free General Electric Drive Selection Kit ☐ for extruding ☐ for calendering ☐ also include a free 13 x 29" reproduction of the above painting suitable for framing.

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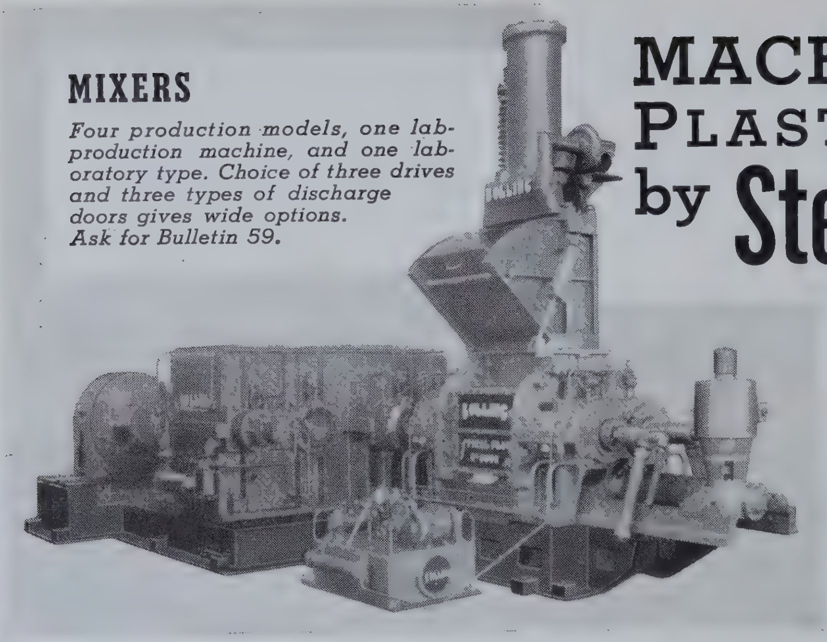
Progress Is Our Most Important Product

GENERAL ELECTRIC

MACHINERY for the PLASTICS INDUSTRY by Stewart Bolling...

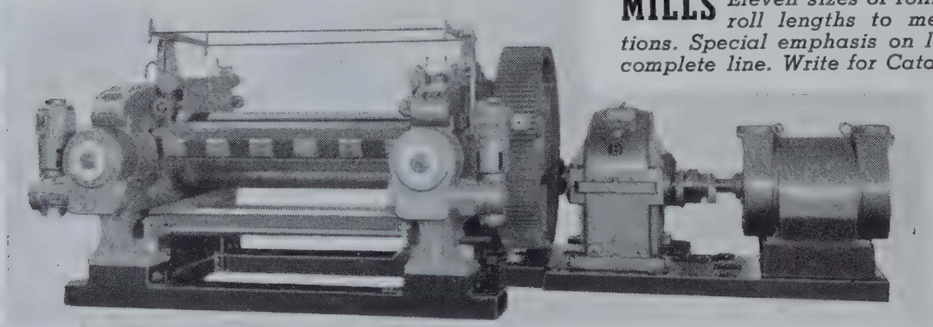
MIXERS

Four production models, one lab-production machine, and one laboratory type. Choice of three drives and three types of discharge doors gives wide options. Ask for Bulletin 59.

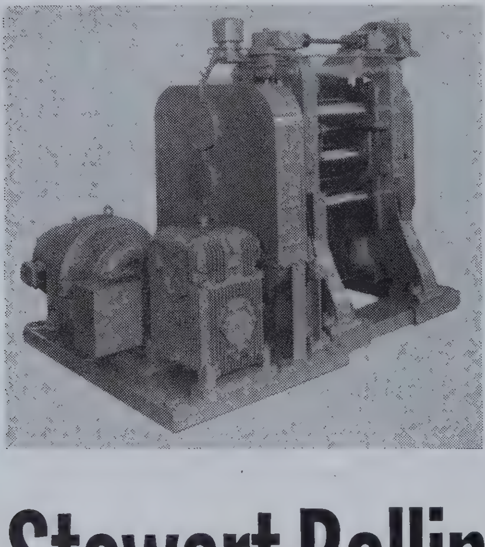


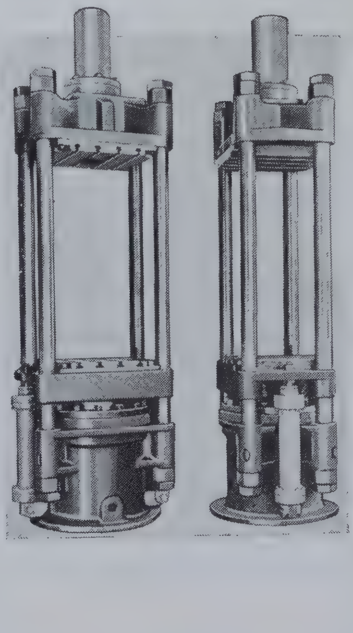
The life of American industry today depends upon its ability to cut costs and increase profit. Stewart Bolling answers that challenge with modern facilities, forward-looking design, experienced (30 years) construction, and a most varied and versatile range of equipment. Catalogs on Bolling's major lines, merely outlined herewith, will prove our case.

MILLS *Eleven sizes of rolls up to 100". Speeds and roll lengths to meet individual specifications. Special emphasis on laboratory mills, a really complete line. Write for Catalog 58-M.*



CALENDERS *2-, 3-, and 4-roll, standard and special designs. Range from 8" x 16" to 22" x 62". Get Catalog 58-M.*

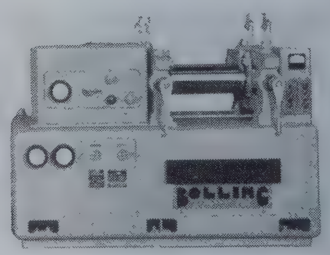




PRESSES *Transfer and compression molding, from 50 to 2500 tons, 14" x 14" up. Get Catalog 58-P.*

←

LABORATORY EQUIPMENT



In all the lines illustrated here, Stewart Bolling makes several laboratory models. Shown is a deluxe 8" x 20" mill. Write for Catalog 58-L, describing what we believe to be the most complete line of laboratory equipment offered today for rubber and plastics. Specials, however, to order.

Stewart Bolling
& Company, Inc.
3190 EAST 65th STREET • CLEVELAND 27, OHIO

Designers and Builders of Machinery for the Rubber and Plastics Industries

Intensive Mixers • Calenders • Mills • Refiners • Crackers • Dust Grinders • Sheeters
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Reifenhäuser opens New Fields in Extruder Design

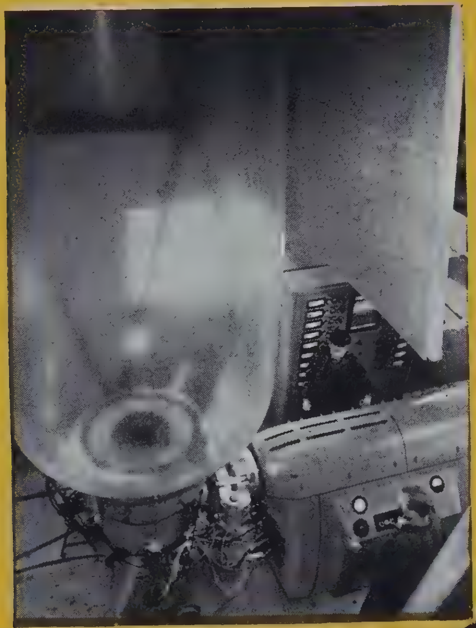
This is the result of applying a system of pre-assembled and interchangeable units in the construction of our extruders, available with screw diameters of 1¼", 1¾", 2½", 3½", 4¾", and 6".

Our complete extrusion plants display also constructional components of the most advanced kind. They are noted all over the world for their high outputs, long and trouble-free working life, and economy in use. As complete productive units they serve for the processing of thermoplastic materials into:-

Sheets, pipes, profiles, mono-filaments, synthetic bristles, lay-flat film, cast film, embossed plastic sheets, and formed articles direct from the extruded sheet. We also supply equipment for the covering of cable, wire, and all other profiles.

Please contact our representative and discuss your extrusion problems with him.

General view of a Sheet Manufacturing Plant



Production of blown film; 11'6" wide lay-flat tubing

Extruder S 120
(4¾" screw diame

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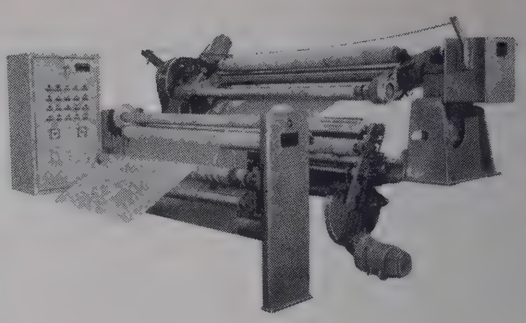
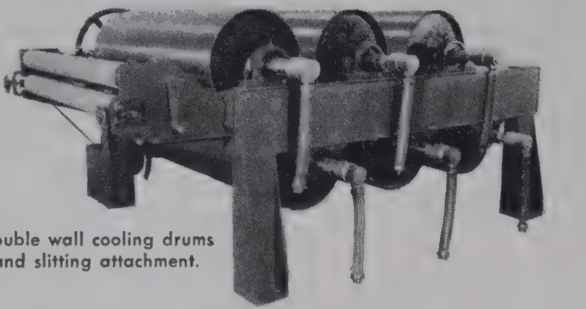
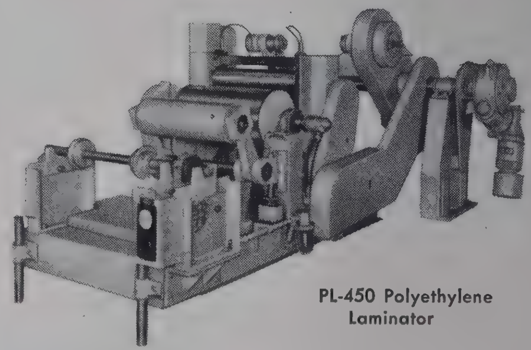

Model 40 Continuous center winder with automatic start for high speed controlled plastic winder.


Double wall cooling drums and slitting attachment.


PL-450 Polyethylene Laminator

THE BLACK-CLAWSON COMPANY
DILTS DIVISION • FULTON, N. Y. • LYRIC—2-4265

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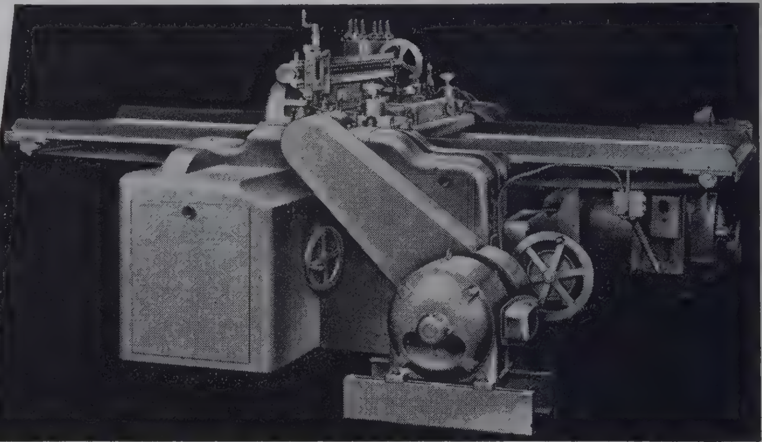
MICRO-SURFACER
(PATENTED)

The Machine that is revolutionizing the sizing of thin sheet materials



SIZES A WIDE VARIETY OF FLEXIBLE, ABRASIVE AND THIN MATERIALS *such as:*

FLOOR TILE . . . TEMPERED HARDBOARD . . . PLASTICS . . . ACRYLITES . . . NITRATES . . . POLYETHYLENE SHEETS, ETC.

CAPACITIES:

STANDARD WIDTHS TO 72"
FEED RATES UP TO 150 FPM
WITH PRECISION ACCURACY.

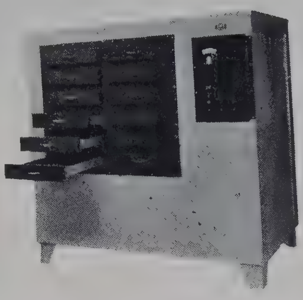
The MICRO-SURFACER is equipped with a Carboloy knife cutterhead which rotates at 4500 RPM, and a vacuum system that holds flexible and very thin stock firmly during the sizing operation. Adequate power allows it to make heavy cuts at fast feed rates. The variable feed is suitable for a wide range of materials. Stock is transferred in and out of machine by built-in conveyors. A built-in knife grinder and other features hold maintenance to a minimum. An efficient exhaust system eliminates grit and dirt. The MICRO-SURFACER has been thoroughly proved as a large volume, precision sizer in numerous applications. This machine can save you money through the faster, better sizing of thin sheet material.

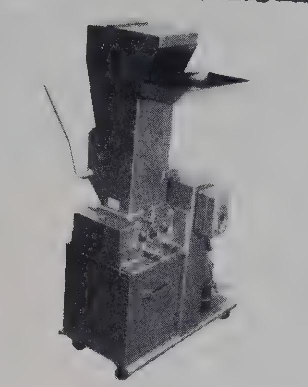
Please consult us concerning any possible application. Send in your material for both production and tolerance testing.

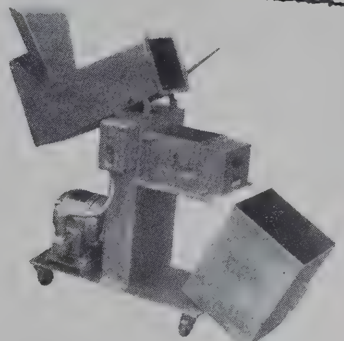
BUSS MACHINE WORKS, INC.
A Subsidiary of Greenlee Bros. & Co., Rockford, Illinois
300 EIGHTH STREET EX 2-2341 HOLLAND, MICHIGAN

IMS STOCK EQUIPMENT

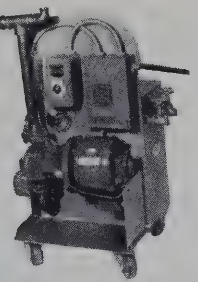
Reed 10D8 Heaters $1198.50
Reed 10D12 Heaters $1995.00


Special Nylon Drying Oven — Provides Maximum Drying Capacity for All Thermoplastics Shipped from stock
$1885.86


M-4 5⅜" x 8½" Throat All-Purpose Grinder 2 HP
Complete $788.50


M-3 6-1/2" x 7" Throat Lowest Cost Sprue and Parts Grinder 1 HP
Complete, only $598.50

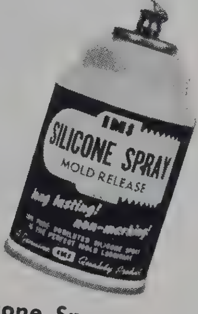
6" Gate Cutters
Each $3.65


Low Cost Injection Mold Circulator.
Complete $369.50

for the Modern

INJECTION MOLDER

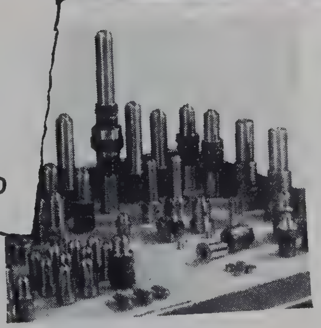
Mold Clamp Sets
Per set of 24 pcs. $60.20

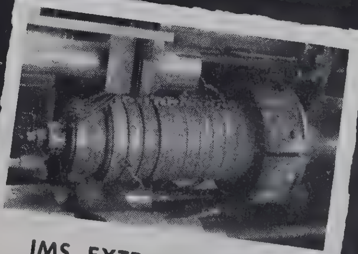


Silicone Spray Mold Release
Per Doz. (Postpaid)
$18.00

Remember

Injection Molders Supply Co. specializes on replacement nozzles and heating cylinders for all types of injection machines.


IMS NOZZLES
For All Injection Machines


IMS EXTRA CAPACITY HEATING CYLINDERS
Stock Models for Reed-Prentice Machines
Others to Order.
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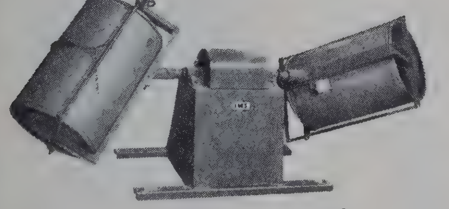
IMS DRUM TUMBLERS

150 lb. 3/4 HP Model T-2	$ 595.00
300 lb. 2 HP Model T-2B	$ 897.50
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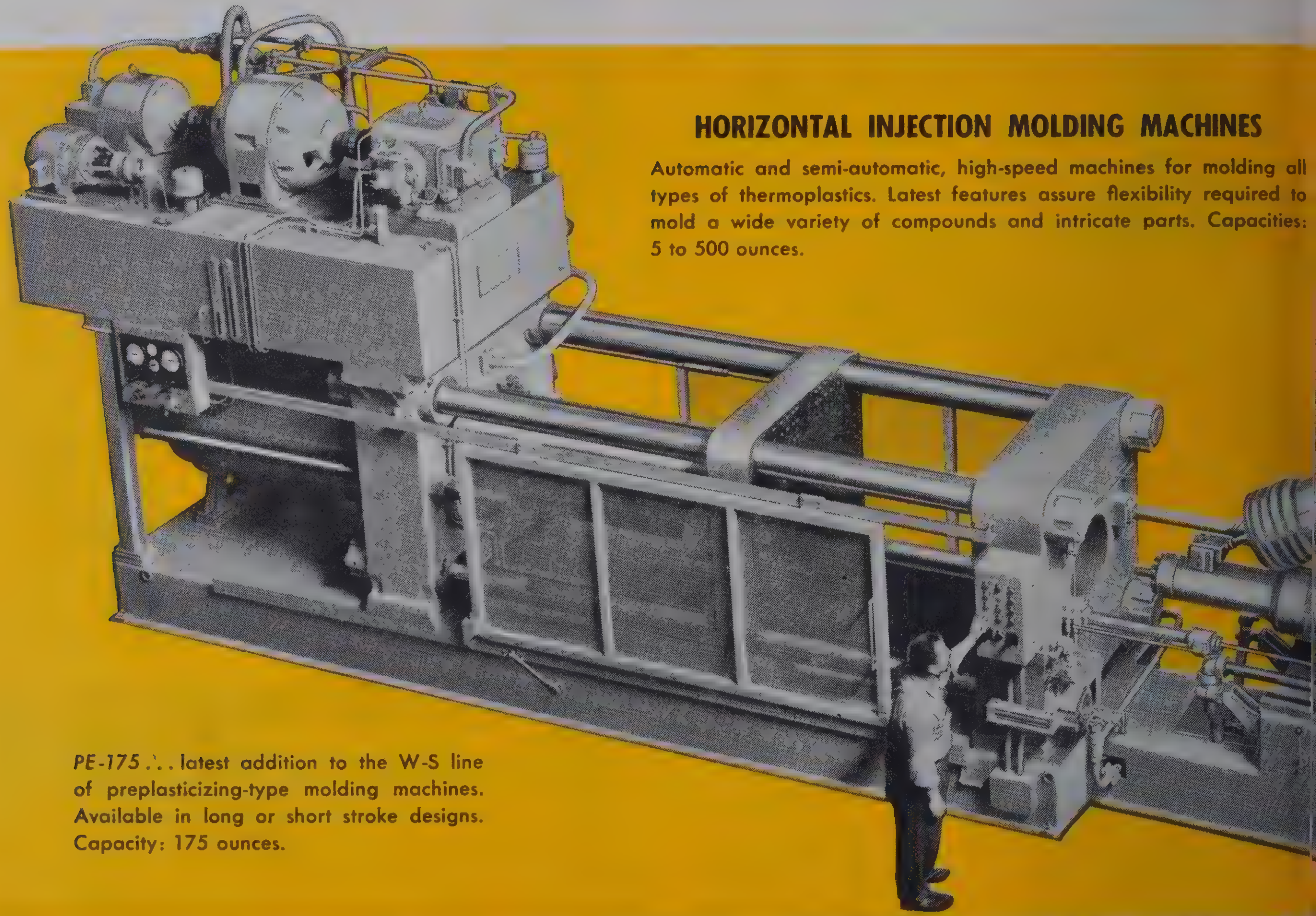
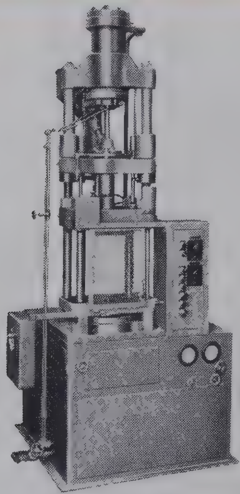
Watson-Stillman moldin



HORIZONTAL INJECTION MOLDING MACHINES

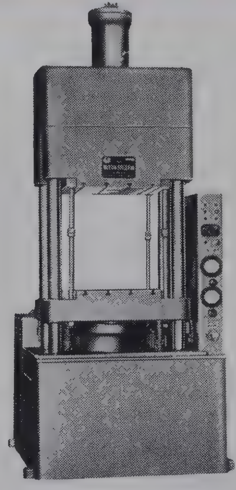
Automatic and semi-automatic, high-speed machines for molding all types of thermoplastics. Latest features assure flexibility required to mold a wide variety of compounds and intricate parts. Capacities: 5 to 500 ounces.

PE-175 . . . latest addition to the W-S line of preplasticizing-type molding machines. Available in long or short stroke designs. Capacity: 175 ounces.



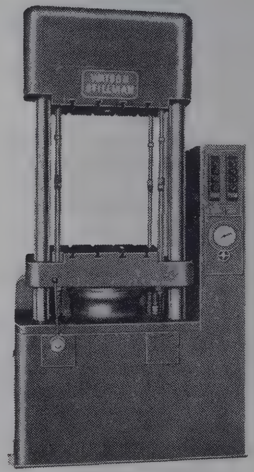
VERTICAL INJECTION MOLDING MACHINES

Designed to meet the need for low-cost high-speed production of small intricate moldings. Also well adapted to molding parts requiring inserts. Capacities: 1, 2, 6, 16, 20, 24 ounces.



TRANSFER MOLDING MACHINES

Standard four-column designs incorporating the latest features for molding thermosetting compounds. Ideal for small insert parts and cores. Adjustable opening to accommodate a variety of mold sizes. Capacities: 30 to 2000 tons.

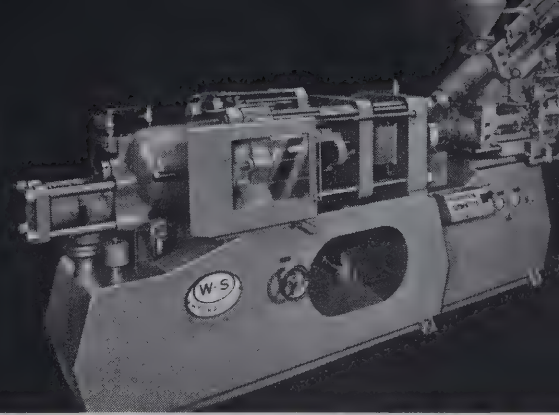


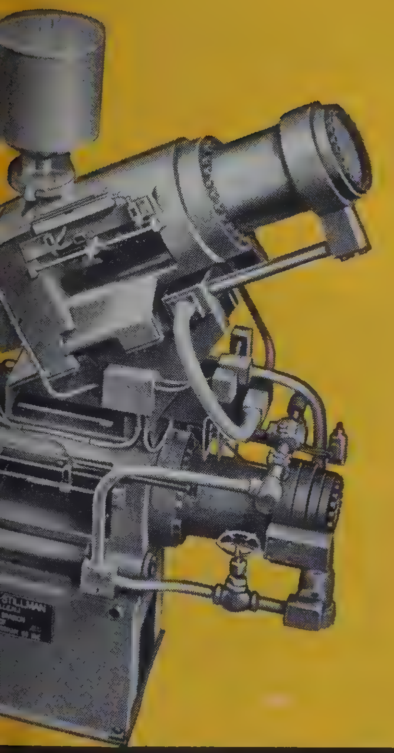
COMPRESSION MOLDING PRESS

Can be converted to transfer press w transfer cylinder. Standard equipment cludes bolsters, parallels, degassing, adj able openings, top and bottom strippe push-button control. Capacities: 50 2000 tons.

machinery

PE-15 . . . fully automatic, preplasticizing-type molding machine with 15-ounce capacity. Advantages: shorter cycles, better control of shot thickness and lower injection pressures.





Watson-Stillman is widely known for its "Completeline" of plastics molding machinery. From this line you can choose a model for virtually any molding requirement...a precision machine, built by specialists in molding equipment. Modern features of design assure high output at low cost.

Also available to "Completeline" users is Watson-Stillman's engineering counsel—a service which has grown out of the company's long association with every branch of the plastics industry. Whether your application requires a standard or special machine, Watson-Stillman engineers will be glad to help you discover the most economical solution.

Write for quotations, or complete details on any of the equipment shown.

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FARREL-BIRMINGHAM COMPANY, INC.
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Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
European Office: Piazza della Republica 32, Milano, Italy
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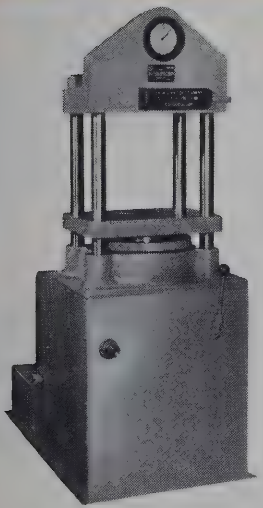
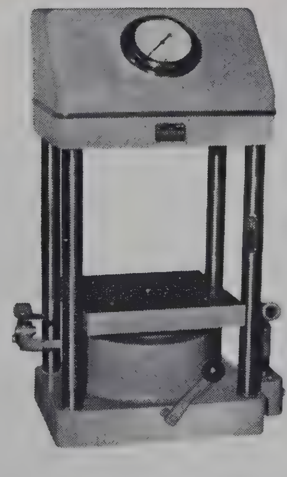
WS-47



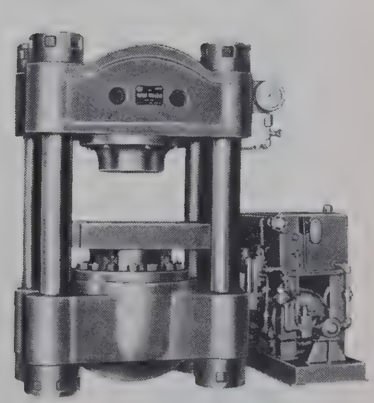
GENERAL-PURPOSE PRESSES

r molding and laboratory work, or for
e as laminating press. Micro pressure
djustment makes them ideal for testing
rposes. Automatic single-cycle control
overns press dwell under pressure. Capac-
es: 30, 50, 100, 200 tons.



LABORATORY PRESSES

Designed for experimental work and wherever pressures of 30 to 100 tons are required on small areas. Ideal for die work, laminating and hot or cold molding. Capacities: 30, 50, 100 tons.



DIE-SINKING PRESSES

For producing dies that will meet the approval of the most exacting molder. Equipped with extra heavy platens, pumping unit, standard control valves, gauge, piping, anvil and inserts. Capacities: 200 to 3000 tons.

a complete line of LAMINATING PRESSES

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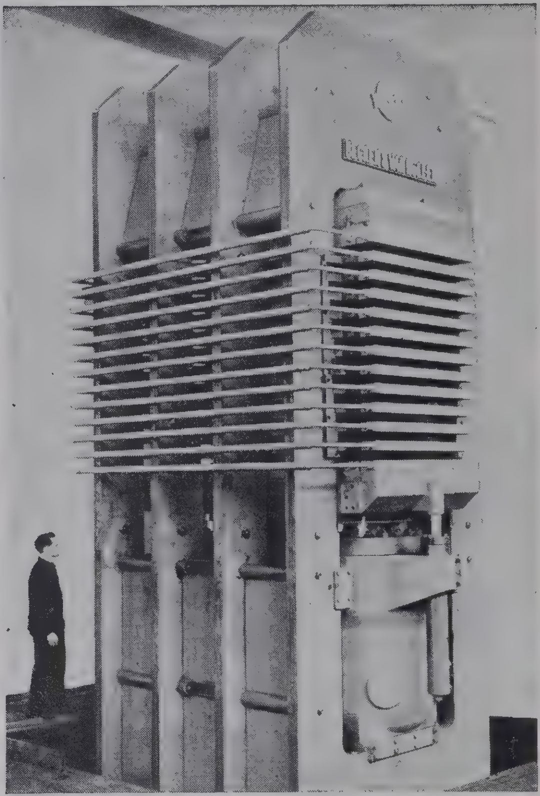

- **laminating presses—available with automatic loading, unloading, sheet handling**
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- **transfer presses**
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Becker & van Hüllen presses range from small laboratory models to huge units. Each is ruggedly built, dependable and available with any degree of automation. For all presses, there is a standard policy of assembly and operation prior to knock down and shipping.

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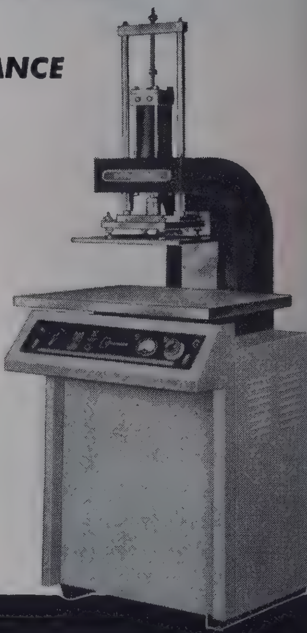

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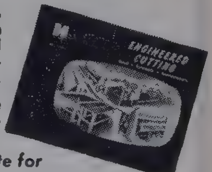

Hobbs-Jacques Hand Shears include a complete line for widths 16" to 10'. Bench and table models, with and without gauges.

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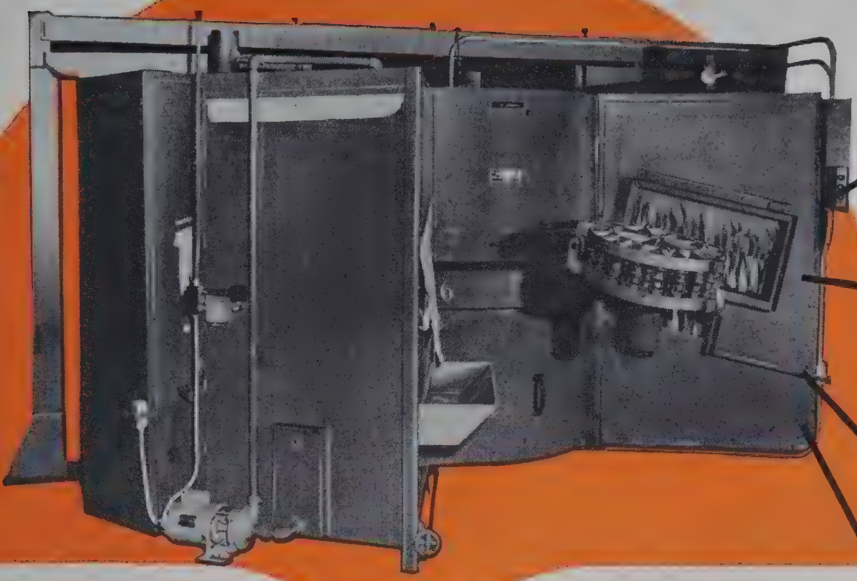

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MOLD UP TO 1620 BIG PROFIT ITEMS PER HOUR . . . LIKE MAGIC

PRESTO . . . PRODUCTION and PROFITS!

Yes, it seems like magic the way this machine converts raw material into finished goods, in one continuous operation. With only one man at the controls, polyvinyl chloride plastisols, vinyl foams, polystyrene expandable beads and polyethylene blends are automatically dispensed and rotationally molded to shape, completely controlled by the automatic features of the machine. The operator need not be a technician, because all the raw materials are scientifically prepared, using all the technological advances made by the nation's foremost companies. Now, any hollow article can be molded from these raw materials, thus creating countless new product possibilities. With a high hourly production and a low hourly cost, it naturally follows that units produced on this machine are BIG PROFIT items.

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We want to demonstrate our "magic" to you. Visit our plant and let us mold YOUR PRODUCTS, right before YOUR EYES . . . like "magic".

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Machines are available with a 15", 25" and 75" molding area, capable of molding items eight times larger than previously thought possible, such as the unicorn, shown here. Imagine, it's automatically molded in one operation!

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LATEX DIPPING	STEEL AND ALUMINUM	PLASTIC INJECTION	SPECIAL AUTOMATIC

ENGINEERING AND

for complete

Farrel-Birmingham makes a wide variety of machines for processing plastics. In addition, the company is prepared by experience to engineer complete plants or units of plants.

The two layouts diagrammed here, were developed for polyethylene compounding and are typical of the projects handled from start to finish by the company's process engineering division. The conventional system includes a Banbury mixer which is automatically fed and discharges directly into an extruder. Material is extruded in strip or strand form, then diced in a dicing machine. In the alternative setup, a pelletizer replaces the extruder and pellets are cut under water.

The process engineering division offers the following engineering services on the usual consulting-fee basis:

1. Prepare a detailed analysis of the project, including (a) description of the operation, (b) flow diagrams and layouts, (c) studies of established and new practices with recommendations, and (d) cost estimates covering requirements for manpower, materials, services and capital investment.
2. Prepare all drawings and specifications for machinery; machinery foundations; structural supports; electric, steam, water and air services; material-handling equipment and storage facilities.
3. Obtain all necessary quotations.
4. Purchase auxiliary equipment, such as conveyors for delivering raw materials to the processing machines and subsequent take-away of finished or semi-finished product; also machinery and equipment for cutting, cooling, stacking, dicing, etc.
5. Supervise the installation and start-up of all equipment.

Details of setups shown or information on individual machines supplied on request.

FARREL-BIRMINGHAM COMPANY, INC.
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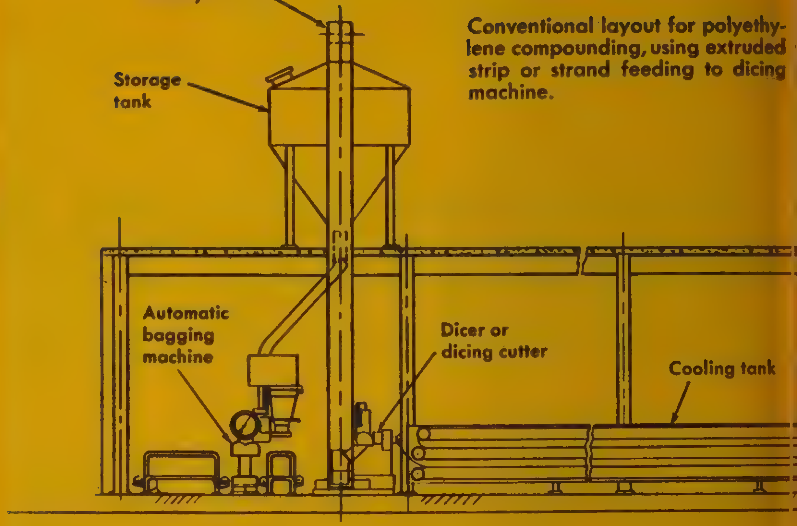
Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.

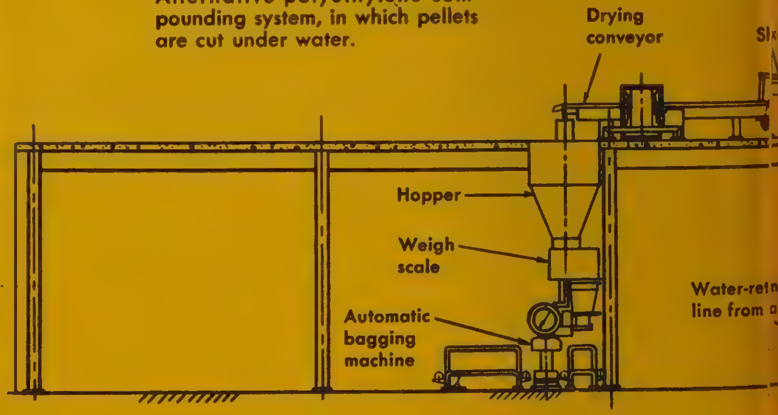
Sales Offices: Ansonia, Buffalo, Akron, Chicago, Ann Arbor (Mich.), Los Angeles, Houston, Atlanta

European Office: Piazza della Republica 32, Milano, Italy



Conventional layout for polyethylene compounding, using extruded strip or strand feeding to dicing machine.

Alternative polyethylene compounding system, in which pellets are cut under water.



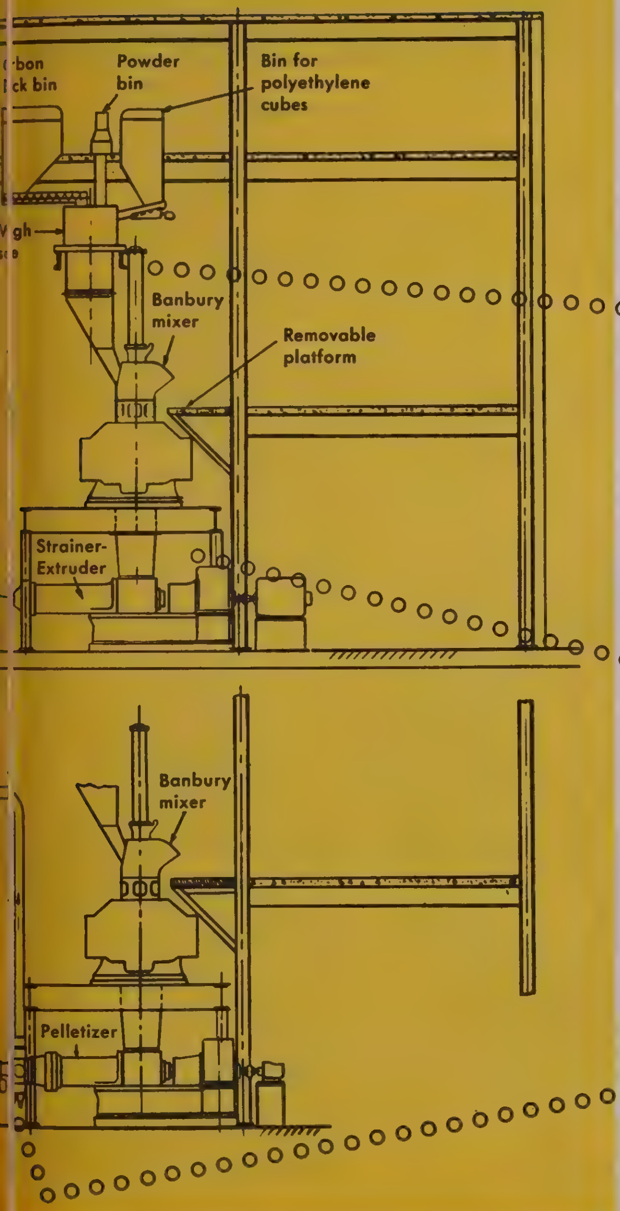
FARREL PRODUCTION UNITS

Banbury Mixers • Roll Mills • Calenders • Extruders • Plasticators • Pelletizers • Injection, Compression and Transfer Molding Machines • Hydraulic Presses and Other Equipment.

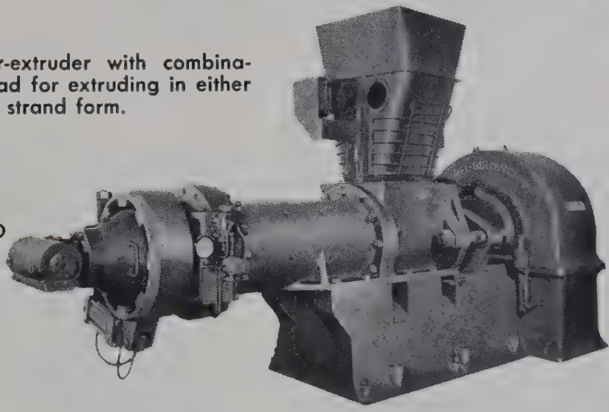
FARREL ®

EQUIPMENT

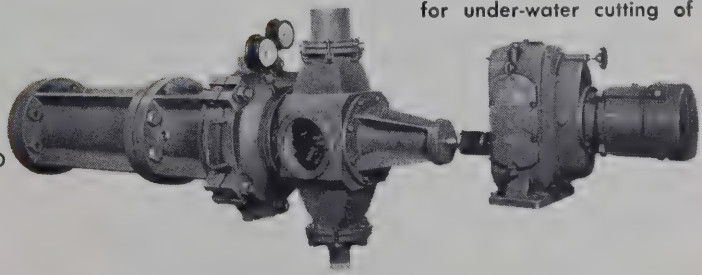
processing setups



Latest type Uni-drive Banbury mixer with hydraulically operated drop door for batch discharge.

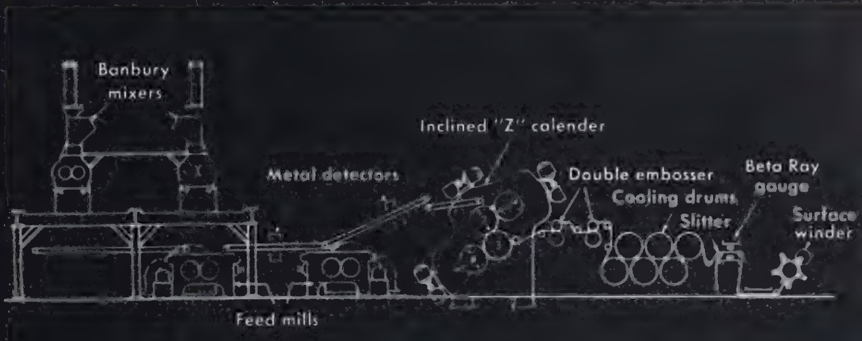


Strainer-extruder with combination head for extruding in either strip or strand form.



Close-up of special pelletizer head for under-water cutting of pellets.

arrel-Birmingham also designs and manufactures equipnent for processing plastic film and coating. The size and lesign of the Banbury and mills assure an even flow of roperly conditioned material to the calender. Calender is lriven by an adjustable-speed motor so that output speed nay be regulated according to the gauge of stock being run.



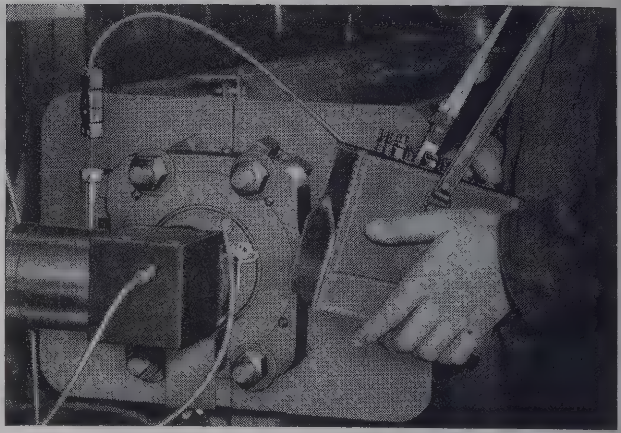
Check **Actual** Stock Temperatures

Quickly

Accurately

With T-E's Three-Unit Package

"MiniMite" Pyrometer Indicator



COURTESY—NATIONAL RUBBER MACHINERY CO.
Checking stock temperature with T-E's three-unit package

For fast, convenient and highly accurate quality control of plastic extrusions—T-E's three-unit, temperature measuring package is ideal. With it you can check actual stock temperatures—and then correlate these to controllers for correct settings. It helps you avoid production losses during start-up or when ambient conditions vary. The package includes T-E's (1) "Plastic Melt" thermocouple, (2) "MiniMite" Portable Pyrometer Indicator and (3) extension wire with jack connector. With the "Plastic Melt" thermocouple installed in the extruder, the "MiniMite" can be connected in seconds to provide a rapid reading. Accurate to ¼ of 1% of scale range, the four lb. "MiniMite" can also be used to check other thermocouples or to calibrate controlling instruments.

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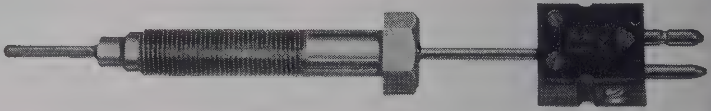
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.



T-E's "Plastic Melt" Thermocouple

TRAY DRYER FOR NYLON
USING DEHUMIDIFIER
(Model N 1330-5)

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HIGH QUALITY
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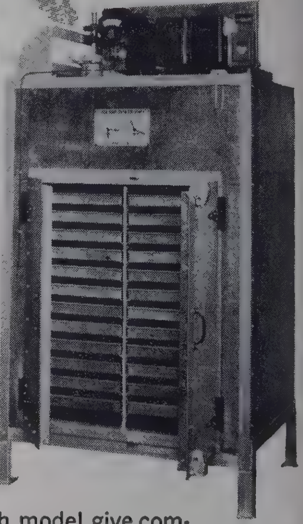
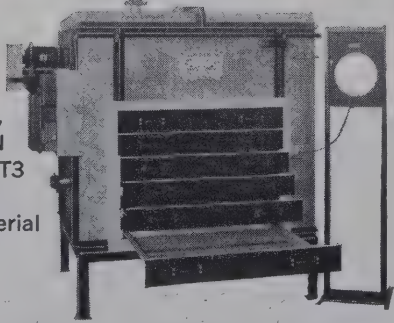


CABINET
TRAY DRYER
(Model 1330—T2)



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For preheating
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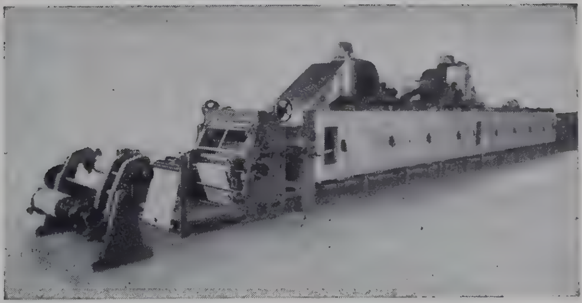
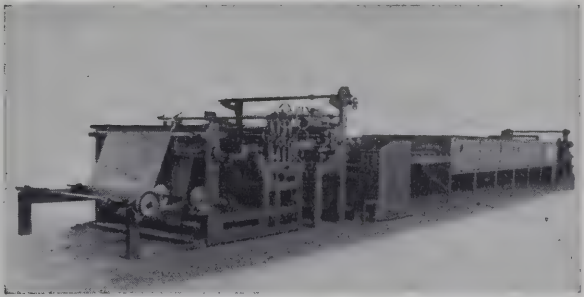
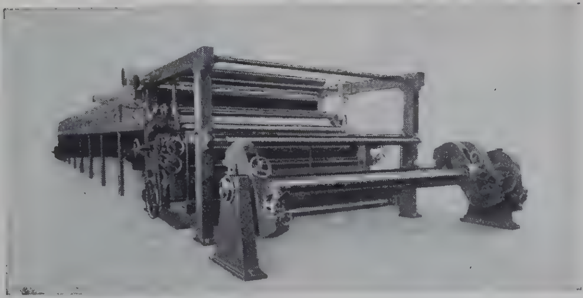


Universal Coating and Impregnating Machine 4900/1



PVC Coating Machine 6084/1

Film Casting Machine, band type 3281/1



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up to 3500 mm working width 4070/1

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scientifically designed to assure uniform material distribution, thereby producing quality and quantity of sheet to the most exacting requirements.

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chrome-plated rolls are power adjusted, hydraulic or air. Uniform temperature control assures superior sheet production.

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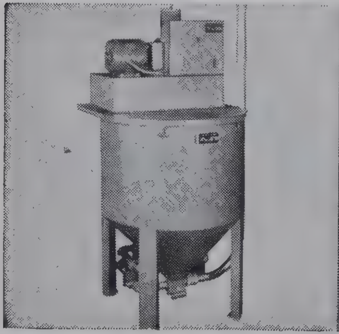
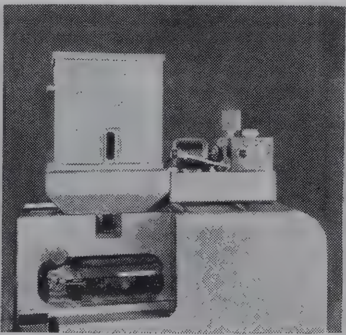


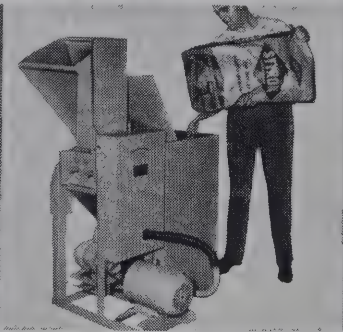
1 Hopper-dryer and Jet hopper loader

More production, lower costs, higher products quality because of properly controlled conditioning of material, no compressed air. Easy installation in minutes.



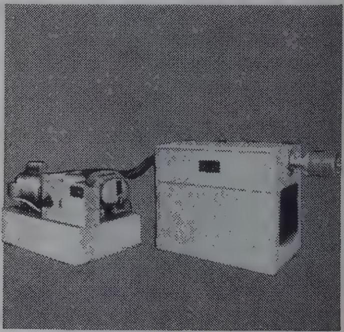
2 Thoreson-McCosh Hopper-dryer

Dries and preheats material at less cost than conventional drying ovens. Easy installation on standard injection and extrusion machines. No compressed air.



3 Shearway granulator, blender and loader

Granulates and loads in one operation. With our Hopper-dryer it is the most effective drying, loading, granulating, blending unit obtainable. No compressed air.



4 Thoreson-McCosh new Hi-dri unit

Simple mechanical (no chemicals) dehumidifier for use with our Hopper-Dryers on extremely hygroscopic materials under high humidity conditions, inexpensive.

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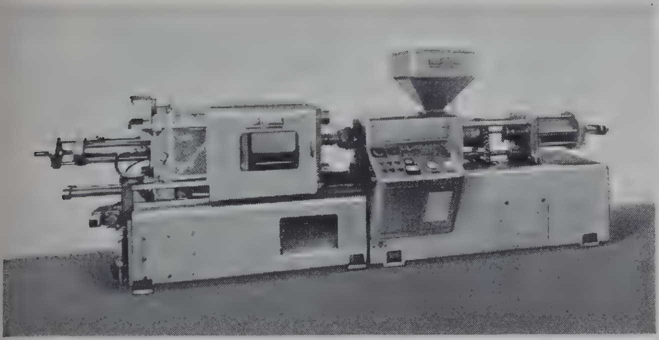
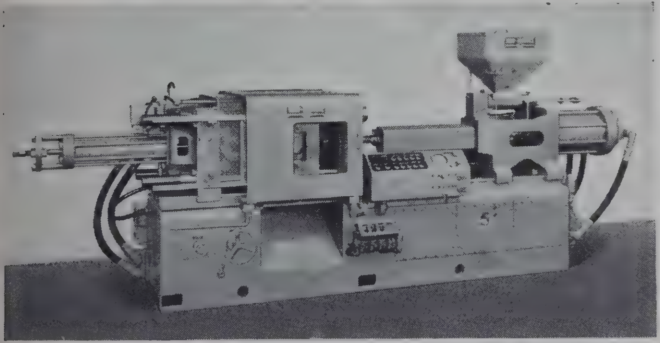
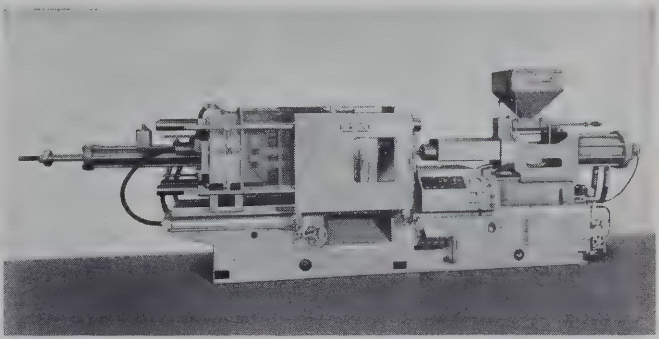

JETFLO 6

JETFLO—Combines superior plasticizing and lower molding temperatures of an extruder with the speed and versatility of an injection machine. Gives you faster automatic molding, higher and more uniform product quality. Equally suited to thin wall container molding or work now done on standard injection machines.

275TA-8/10 oz.—New 275TA gives you longer stroke, increased platen area and space between tie bars to handle larger molds. Low-pressure die closing mechanism protects molds in automatic operation.

350TL-12/16 oz.—Long-stroke model for deep draw molding adjusts between 8½" and 20". Dry cycle cut to 9 seconds, and locking tonnage increased. 325TC is standard 12/16 oz. model, with new 7½" to 14½" adjustable stroke, and dry cycle reduced to 6.7 seconds.


275TA-8/10 oz.


350TL-12/16 oz.

CONDENSED SPECIFICATIONS	JETFLO 6	175T-4/6	175TL-4/6	275TA-8/10	325TC-12/16	350TL-12/16	450T-20/24	600T-32/48
Mold clamping pressure, tons	175	175	175	275	325	350	450	600
Mold clamping stroke	5-8"	5-8"	6-12"	6¼ to 11½"	7½ to 14½"	8½ to 20"	16"	24"
Platen size (W x H)	22 x 24½"	22 x 24½"	22 x 24½"	27 x 27¼"	32½ x 32½"	32½ x 32½"	45 x 40"	54 x 45"
Diameter of tie bars	3"	3"	3"	3½"	4"	4"	5"	6"
Space between tie bars	13½ x 13½"	13½ x 13½"	13½ x 13½"	15½ x 15½"	20½ x 20½"	20½ x 20½"	22½ x 25½"	26½ x 30½"
Rated casting area, square inches	75	75	75	125	150	150	200	300
Plasticizing capacity, pounds per hour	100	75	75	120	135	135	150	180
Dry cycle time, seconds	1.3* 2.9†	5.7	7.2	8	6.7	9	18.6	21

*minimum stroke
†maximum stroke

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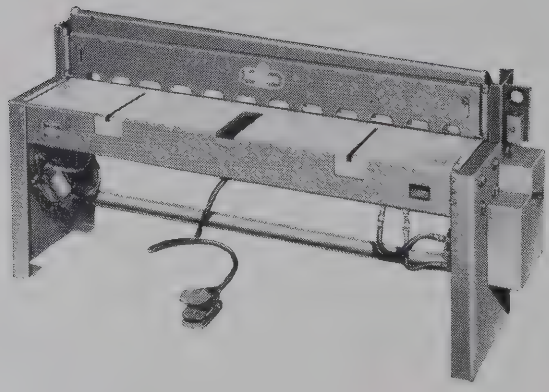
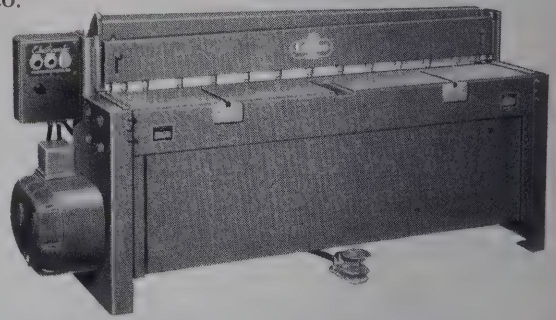
Cutting plastic is "duck soup" when you use Famco squaring shears. Constructed of all steel, these Famco shears have four-edged knives that can be reversed to give you four times the cutting life of single-edged knives. And what a selection! 22 standard models with cutting widths 22 to 96 inches. Where the standard model will not meet your requirements contact our engineering department for special shears. If you want shear accuracy and speed, select a Famco.





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Famco air shears are simple to operate, and easy to use. All steel box design provides rigid support. Rounded corner design eliminates sharp and protruding surfaces. Air shear mechanism consists of: pressure regulating valve; solenoid operated air valve; air filter and gauge; muffler and safety switch. Cutting widths 36″ to 72″.

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- **PNEUMATIC SHEARS**

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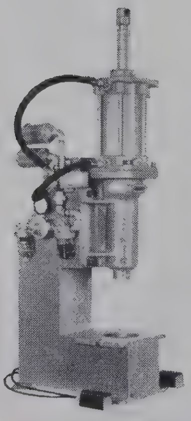

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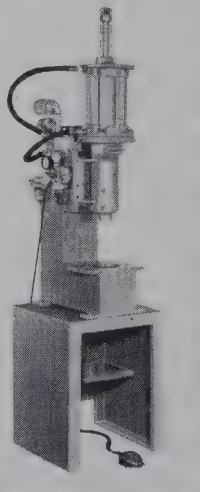
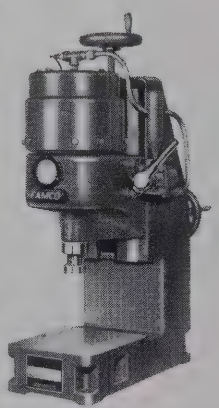
Famco double acting air presses are designed to give users greater flexibility and accuracy. Rugged and powerful, these air presses incorporate every feature needed to give you greater production at lower costs. 15 different sizes to select from, either bench or floor type.





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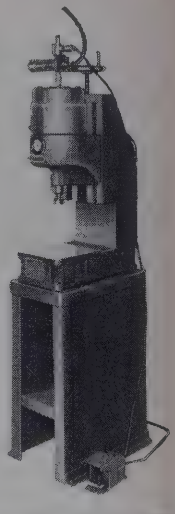
Precision-built Famco single acting air presses are designed especially for continuous industrial operation. Designed to perform hundreds of operations. 28 different models available either bench or floor type with single or double electrical controls.



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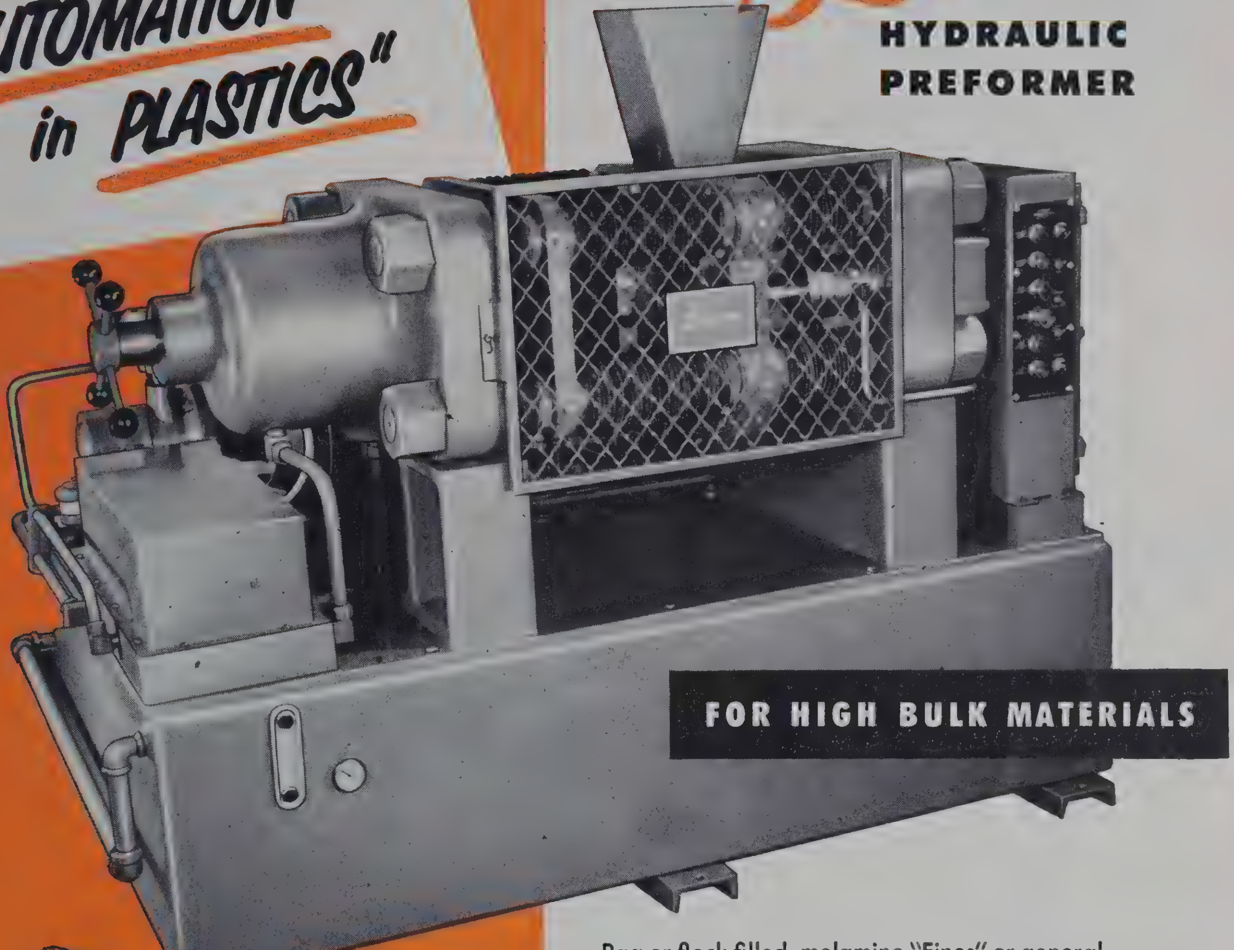

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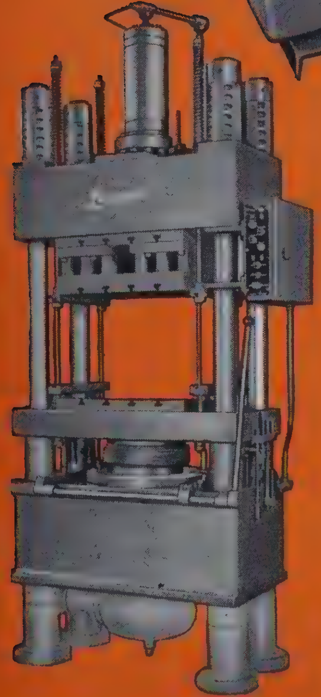

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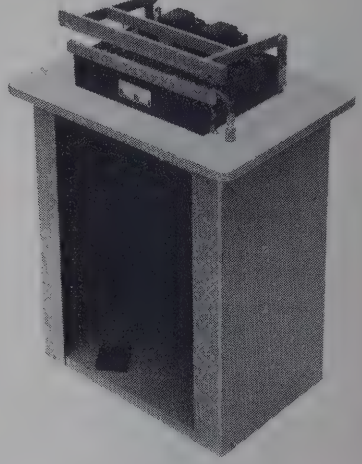

Vertrod Thermal Impulse Sealers are manufactured under one or more of the following U.S. patents: 2,460,460; 2,479,375; 2,509,439; 2,574,094; 2,574,095; 2,630,396; 2,633,443; 2,640,796; 2,640,798; 2,650,183; 2,675,054; 2,682,294. Canadian Patents 468,140 and 496,237. Other Patents Pending.

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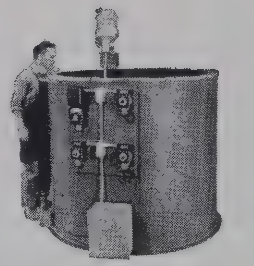

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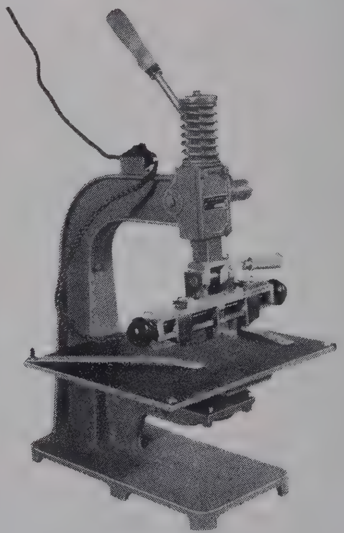

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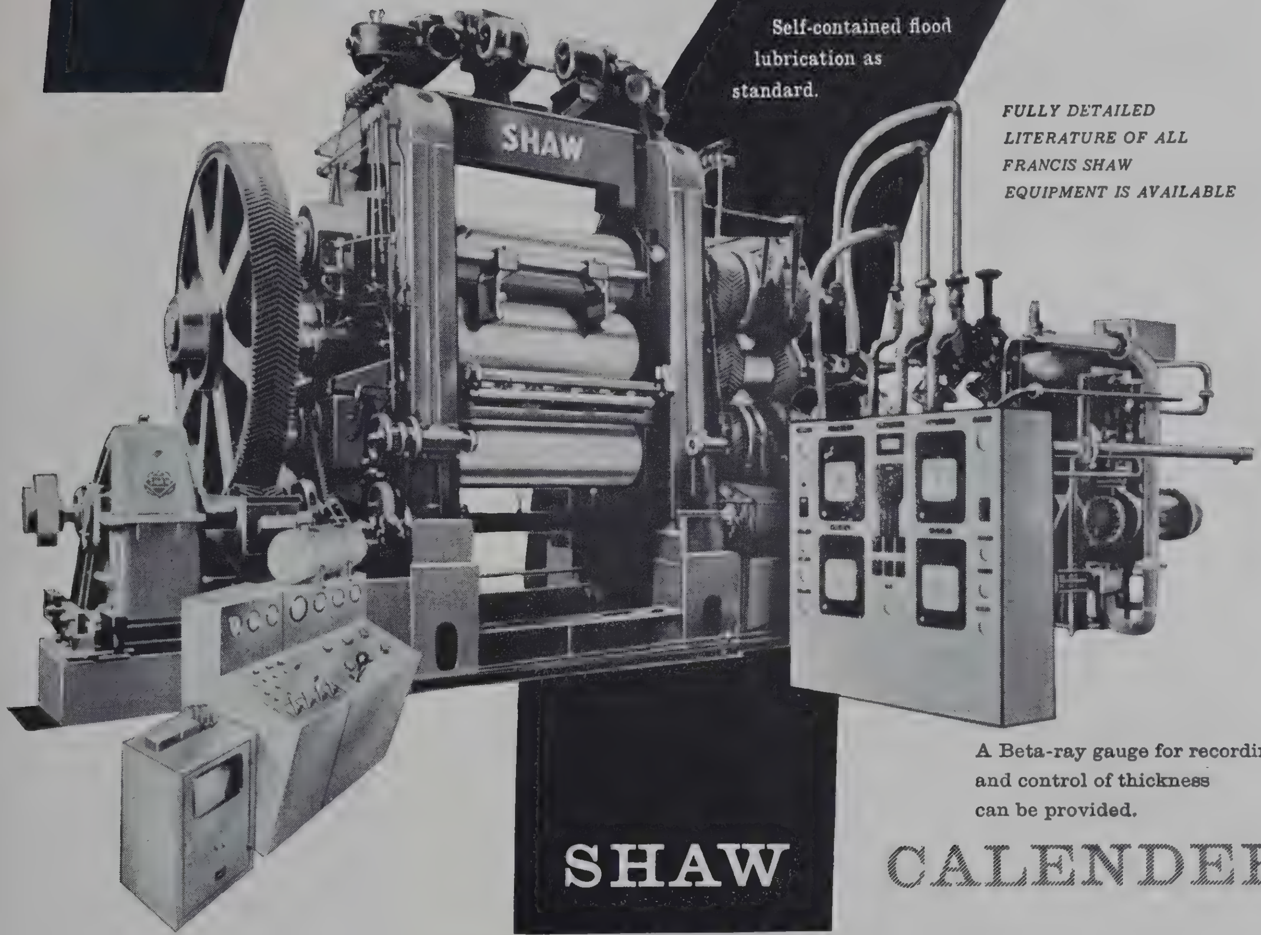

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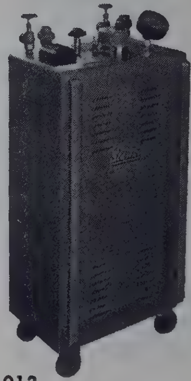

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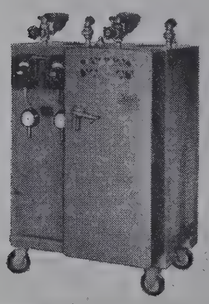

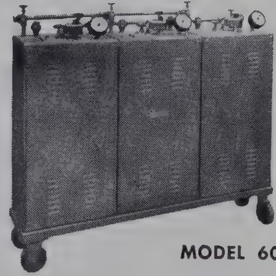

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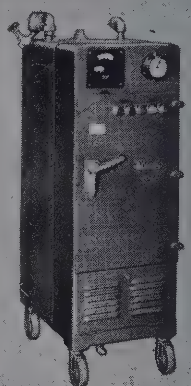

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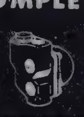

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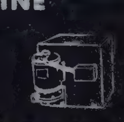

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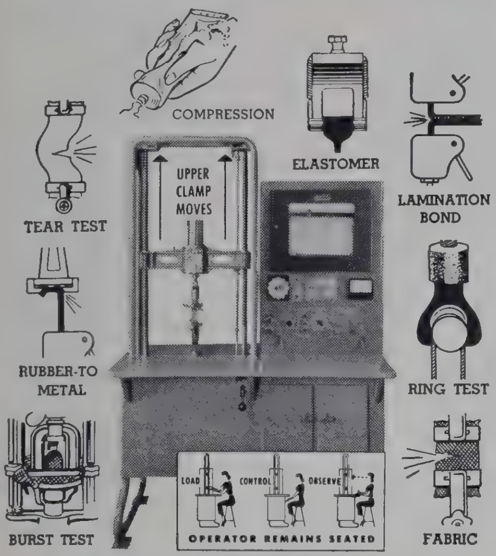

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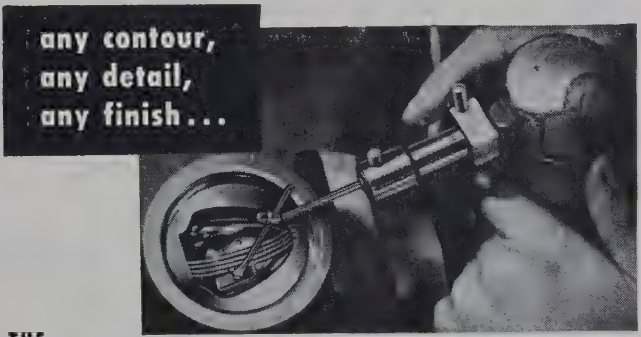

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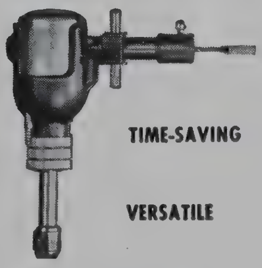

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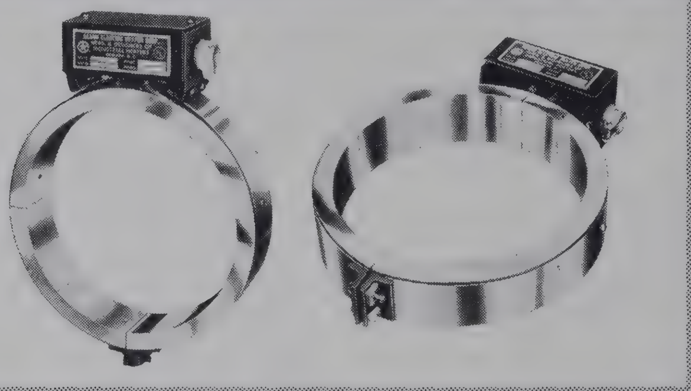

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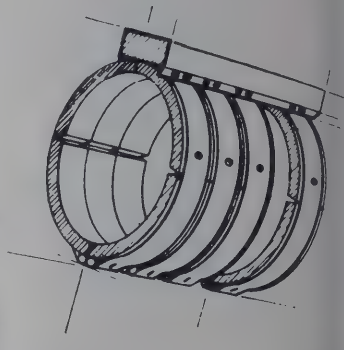

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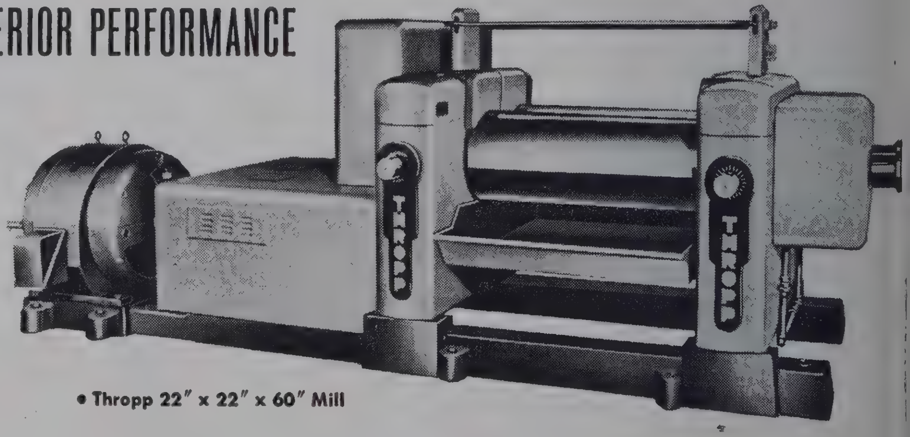

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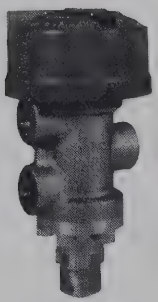

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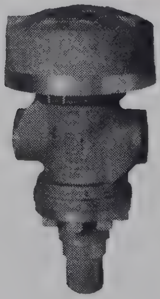

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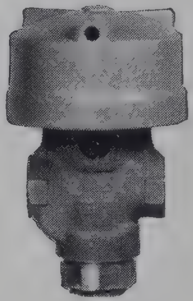

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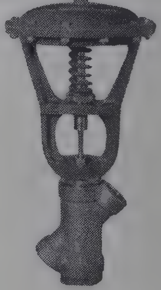

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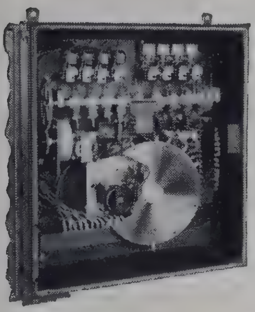
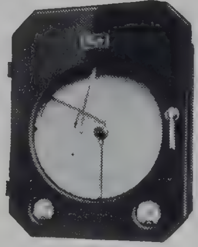
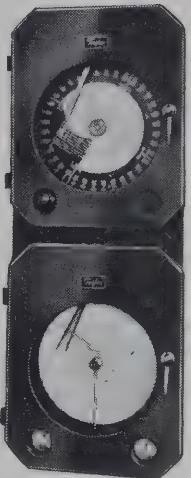


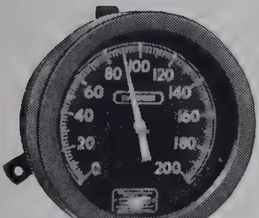
aylor FLEX-O-TIMER* Cycle Controller. perates compression presses automaically at the push of a start button. Actutes switches, turns valves, and performs any other operations involving temerature, pressure, mechanical motion, lectrical energy or any combination of hese. Settings can be quickly changed.



Taylor FULSCOPE* Controller. For twenty years the standard of dependable, accurate control of temperature or pressure. Will hold precise temperatures throughout the processing of any compression molded product, from small batch to long continuous run. Control points easily changed for different products.

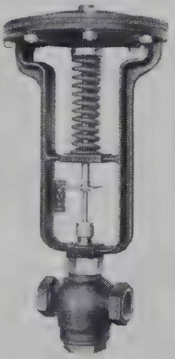


FULSCOPE Time Schedule Controller. Will repeat exactly any predetermined program involving temperature, pressure, flow or level, or any two of these. Controls rate of rise, hold periods, and rate of fall, in any desired sequence. Ideally suited for printed circuit or other laminar molding. Ensures uniform product.



ylor Triple Duty Dial. 6″ Dial Indicar can be used for three process variaes—temperature, pressure and load. ependably accurate throughout the nge span. Fume and moisture proof se may be face or flush mounted, on nel or field case. Electric alarm mechisms optional.

Taylor BI-THERM* Dial Thermometer—a quick, reliable bi-metallic thermometer, ideal for applications where an easy-reading, low cost, direct connection instrument is desired. Unaffected by ambient temperatures—accurate to ±1% of scale. 3″ or 5″ dials. 4″, 6″, 9″ and 12″ stems. Range minus 40° to plus 750°F.



Taylor HI-FLOW* Valve. Has greater flow capacity than conventional valve of same size. Net flow area is equal to 90% of the same size standard pipe. Simple design keeps maintenance to a minimum; rugged construction assures you a long service life. Inherent tight shut-off. Sizes ½″ through 2″, direct or reverse acting.

Taylor Instrument Companies, and their subsidiary Taylor-Emmett Controls, Inc., offer you a wide range of instruments for completely coordinated control or simple timing and sequencing. Dependable, accurate and ingeniously designed, these instruments are all available through your experienced Taylor Field Engineer. Write Rochester, New York or Toronto, Ont.

*Trade-Mark

Taylor Instrument Companies

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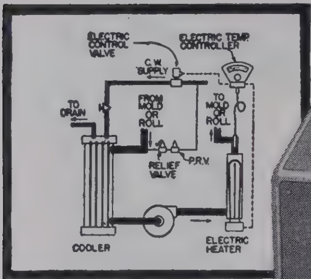
Complete automatic mold and cylinder temperature control
. . . with SARCOTROL



▲ Schematic diagram of control circuit in the Sarcotrol Model MC-1, Single Unit. Model MC-2, Dual Unit, is equipped with two of these circuits. Model MC-3 has three complete circuits.

Sarcotrol Model MC-2 Heating and Cooling Unit for injection molds, cylinders, rolls and drums. Fully enclosed. Easily seen, completely accessible control knobs. ▶

With Sarcotrol Automatic Temperature Control a dial setting gives you *quality control*, and helps to free your production from the problems of *sticking, shrinkage* and *crazing*.

Sarcotrol helps you step up output, and cut down rejects. New, higher cooling capacity makes the Sarcotrol suitable for calender rolls and large molds.

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SARCOTROL GIVES YOU 8 MAJOR ADVANTAGES

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4. Heat exchanger cooling adjustable to load
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6. New economy of electricity and water
7. Sensitive system reaction — fast response
8. Automatic maintenance of correct temperature to protect product quality

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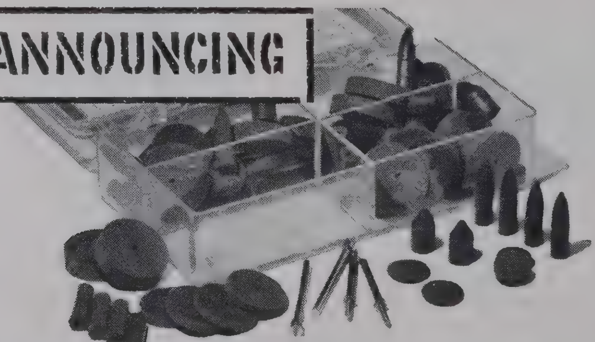

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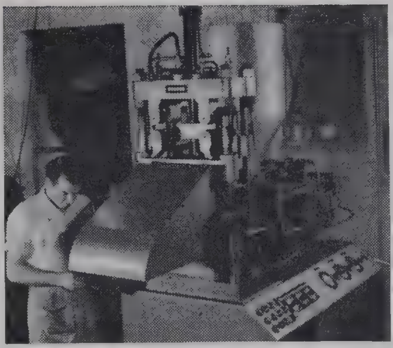
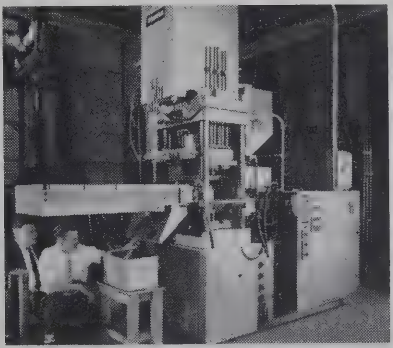
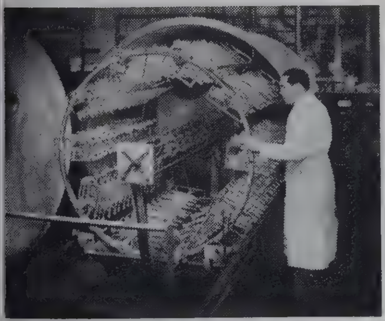
Stokes Truly Automatic Injection Molding Machines. The 2-ounce Model 701 and 6-ounce Model 703 mold, de-gate, eject and sort automatically without operator attention. Positive nozzle shut-off eliminates "drooling", permits full-pressure prepacking of injection cylinder for precompressed molding and uniform plasticizing. Positive ejection, 3½-second dry cycle, simplified die set-up. Bulletin 203.

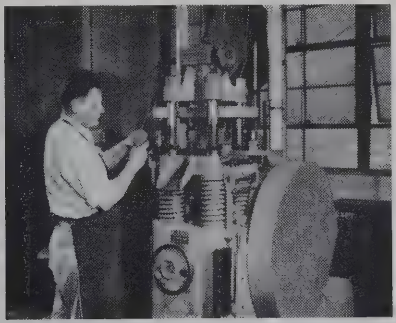


Stokes Fully Automatic Compression Molding Presses provide highest attainable molding economy plus precision and flexibility. The Model 741 is available in 50, 75, 125 (illustrated), 150 and 200 ton models. Other Stokes automatic presses include Model 800 in 15 and 25 ton sizes, Model 725 in 25 ton size, and Model 742 closure presses in 50 and 75 ton capacities. Catalogs 200, 201 and 202.

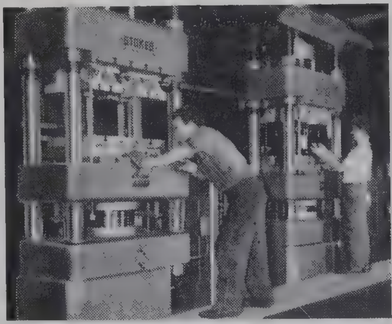




tokes Vacuum Metallizing Systems are vailable in 24-, 36-, 48-, and 72-inch illustrated) models. Imparts brilliant, ong-lasting metallic finish at minimum ost. Opaque coating permits use of scrap lastic. No buffing or polishing required n metal parts. Efficient vacuum system peeds production . . . up to 4 cycles per our. Catalog 780.



Stokes Preform Presses, such as the Model 294 shown here, are available in a choice of 4 single-punch models, 8 rotary types, plus 50 ton and larger hydraulic models. Preforms are made in the range from small button sizes to those weighing as much as 10 pounds. Catalog 509.



Stokes Semi-Automatic Compression and Transfer Presses are fast acting and reliable. Compression and transfer presses are available from stock in 50-, 100-, 200-, and 300-ton sizes (200-ton press is shown). Transfer presses have either top or bottom plunger with 19-, 24-, 40-, and 50-ton force. Catalog 240.

For data, request the catalogs listed with the specific equipment. For application and information assistance, call on the Stokes Advisory Service.

Plastics Equipment Division
F. J. STOKES CORPORATION
5519 Tabor Road, Philadelphia 20, Pa.

STOKES

NATCO

INJECTION MOLDING MACHINES

DEPENDABLE...
FAST CYCLE

The Natco Injection Molding Machines are proven performers and are well known as "The Molders Molding Machine." Each new installation has shown amazing production performance. The Natco "patented" closed-circuit shockless hydraulic system, fast injection rate, high speed clamp action, two-speed injection control, automatic dual voltage heating, big capacity "leakproof" heating chamber and a choice of 20,000 or 30,000 psi interchangeable plungers makes Natco the first choice of molders who want the best. These features plus unequaled dependability designed into the Natco is the answer to better profits in today's competitive injection molding market.

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Natco 300 molds ladies shoe heels in 12 cavity mold . . . a 22 oz. shot

Molding 8 polystyrene wall tile on a 13 second cycle with a Natco 300

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A 22 oz. radio cabinet molded at a rate of 70 per hour with a Natco 400

Natco 400 produces 150 of these 16 oz. polyethylene wastebaskets per hour

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Natco 800 molds 48 oz. impact polystyrene T. V. cabinet backs in record time

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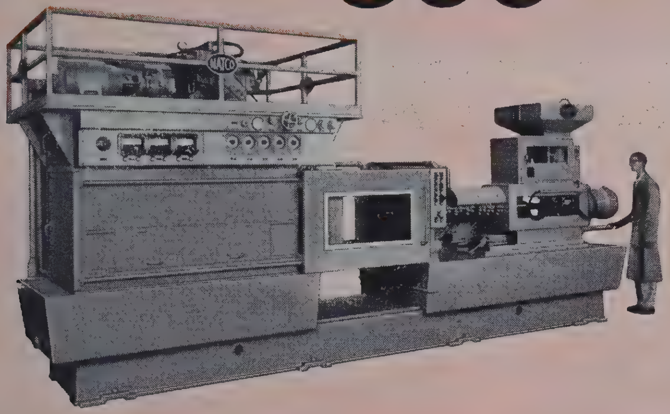
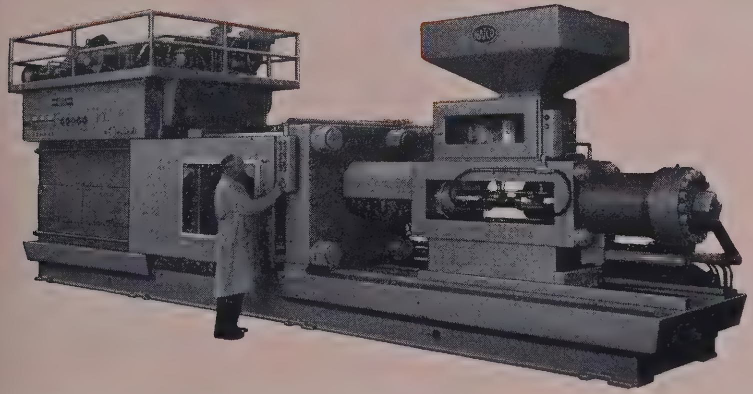


	300
Shot size, ozs.—Single feed	22
Melt Capacity (lbs./hr.)	130
Mold Platens (Inches)	33 x 33
Clearance between Rods (Inches)	21½ x 21½
Clamp Pressure (Tons)	325
Clamp Stroke (Max.) (Inches)	24
Daylight Opening (Max.) (Inches)	42½
Injection Speed (Cu. in./min.)	1125

400

	400	400X	400S
Shot size, ozs.—Single feed	28	28	28
Melt Capacity (lbs./hr.)	165	165	165
Mold Platens (Inches)	38 x 38	38 x 38	38 x 41
Clearance between Rods (Inches)	25 x 25	25 x 25	22 x 25
Clamp Pressure (Tons)	425	425	550
Clamp Stroke (Max.) (Inches)	26	26	26
Daylight Opening (Max.) (Inches)	50	50	48
Injection Speed (Cu. in./min.)	1140	2420	1140

800



	800	800X
Shot size, ozs.—Single feed	80	80
Melt Capacity (lbs./hr.)	350	350
Mold Platens (Inches)	55 x 55	55 x 55
Clearance between Rods (Inches)	36½ x 36½	36½ x 36½
Clamp Pressure (Tons)	850	850
Clamp Stroke (Max.) (Inches)	40 or 55	40 or 55
Daylight Opening (Max.) (Inches)	85	85
Injection Speed (Cu. in./min.)	2000	4000

NATCO

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NATIONAL AUTOMATIC TOOL COMPANY, INC.
PLASTIC MACHINERY DIVISION
RICHMOND, INDIANA, U. S. A.

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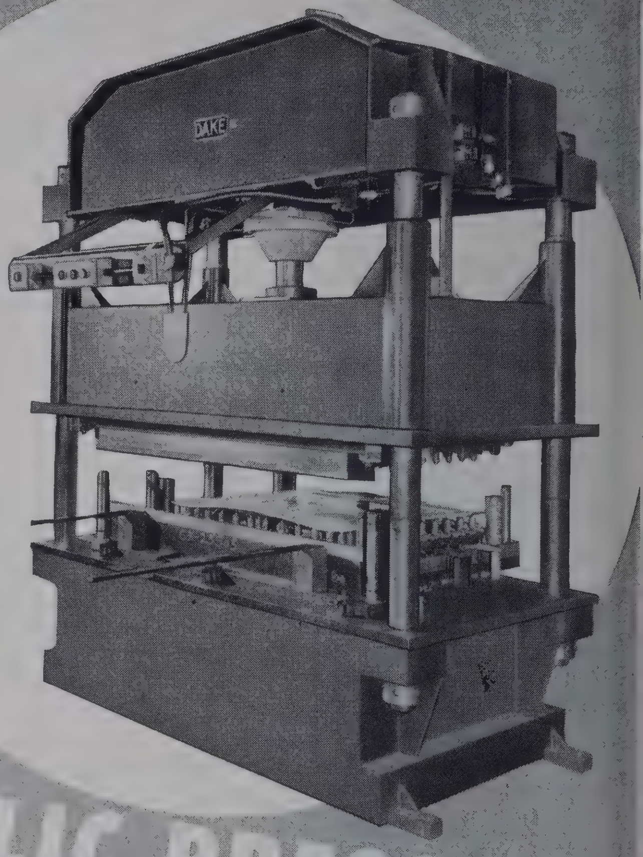
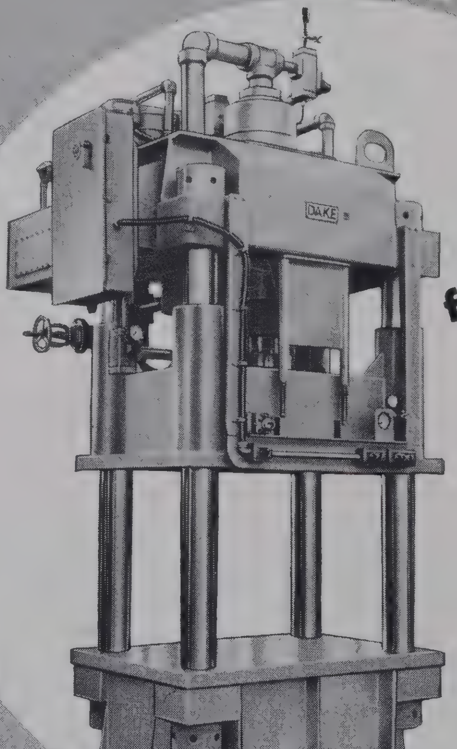


for trimming and piercing vacuum-formed plastics

DAKE HYDRAULIC PRESSES



for molding reinforced plastics

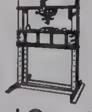
Be a pacemaker in the fast-moving plastics industry with equipment designed to keep production geared to modern trends. Dake Hydraulic Presses speed output and reduce costs. They are job-engineered by men experienced in the plastics industry. These men are ready to help you meet special requirements as well as provide better equipment . . . both for compression molding of reinforced plastics as well as trimming and piercing vacuum-formed plastics. Standard models are electric-hydraulic in operation, with capacities ranging from 25 to 300 tons. They are adjustable for stroke, pressure, temperature and timing. Dual palm-operated controls are standard, providing safety in operation. Dake will gladly work with you in developing whatever special press equipment you need.

For descriptive literature on these presses, write for Bulletins 340 and 352.

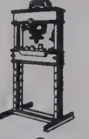
DAKE CORPORATION 641 Robbins Road, Grand Haven, Michigan

DAKE PRESSES

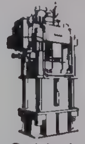
Arbor Presses



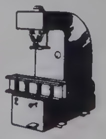
Hand-Operated Hydraulic



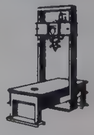
Power-Operated Hydraulic



Guided Platen



Gap Type Presses



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For the application of water dispersions of various resins, such as vinyls, rubbers or neoprenes, to various webs for such uses as paper backup for tapes, decorative papers or industrial fabrics.

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For the continuous saturation and impregnation of one or several webs under complete process control using polyesters, latices, varnishes and silicones—for many important industrial products.

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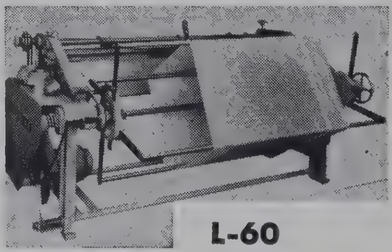

L-60

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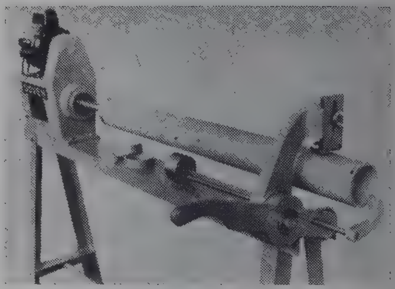

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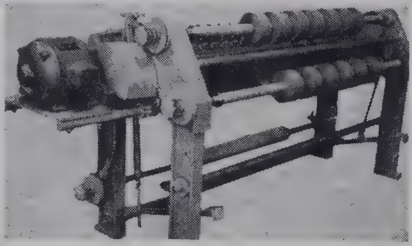

CDR-60

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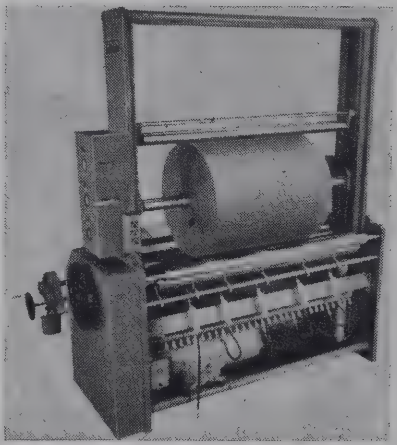
For Plastics, Cellophane, Acetate, Polyethylene, Saran, Paper, Cloth



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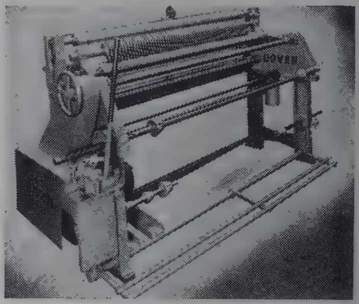
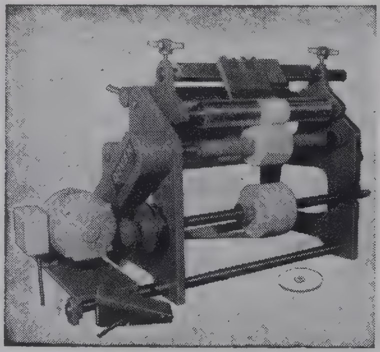
For all Paper Board, Tissue, etc.



CSR-60

SINGLE REWIND SLITTER

For Plastics, Polyethylene, Cellophane, Leatherette, Coated Fabrics, Cloth



BSR-18

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For Teflon, Plastics, Polyethylene, Cellophane, Saran, Aluminum Foil, Condenser Tissue as thin as .00025

BDR-24

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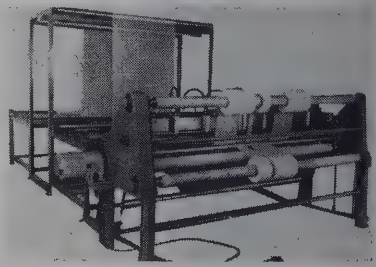

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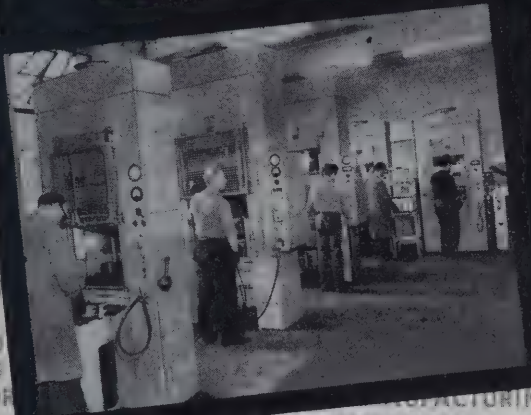
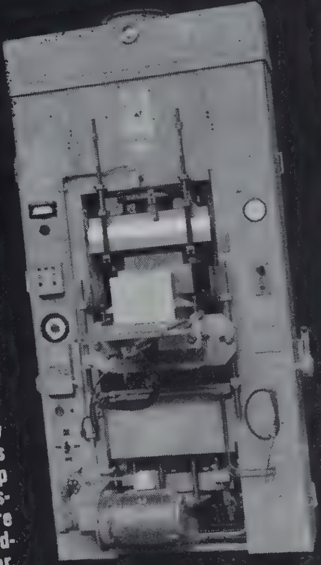


BIPEL Presses offer 8 variable pressure ranges from 24 to 660 tons . . . individual or multiple installations with central drive systems . . . fully or semi-automatic, or manual controls. New fully automatic units (right) are available up to 71 or 168 tons pressure . . . require no more floor space than standard press with operator.



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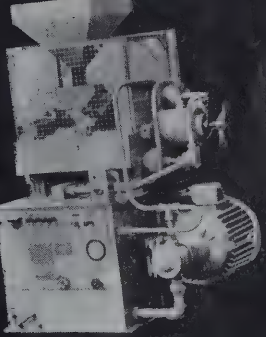
BIPEL Preformers are available in four models, with variable pressure ranges from 13 to 155 tons (2000 to 600 strokes per hour). Preforms up to 6 lbs. may be produced, handling a ton of material per hour. Up to 21,000 small preforms per hour are possible with multi-punch models.



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On this page are listed some of the outstanding American firms who have installed BIPEL equipment. World-wide BIPEL leads the field with over 350 installations in 24 countries!

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HORIZONTAL HYDRAULIC PREFORMERS

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OLDING CORPORATION • ROBOT DEVICES, INC • THE HAAS CORPORA
SION PLASTIC & DIE CORPORATION • GENERAL DIE MOLD CORPORAT
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LWAUKEE PLASTICS, INC • ADAMS PLASTICS • SARATOGA PLASTICS,
ELECTRONICS CORPORATION • PLASTIC PRECISION PARTS COMPANY
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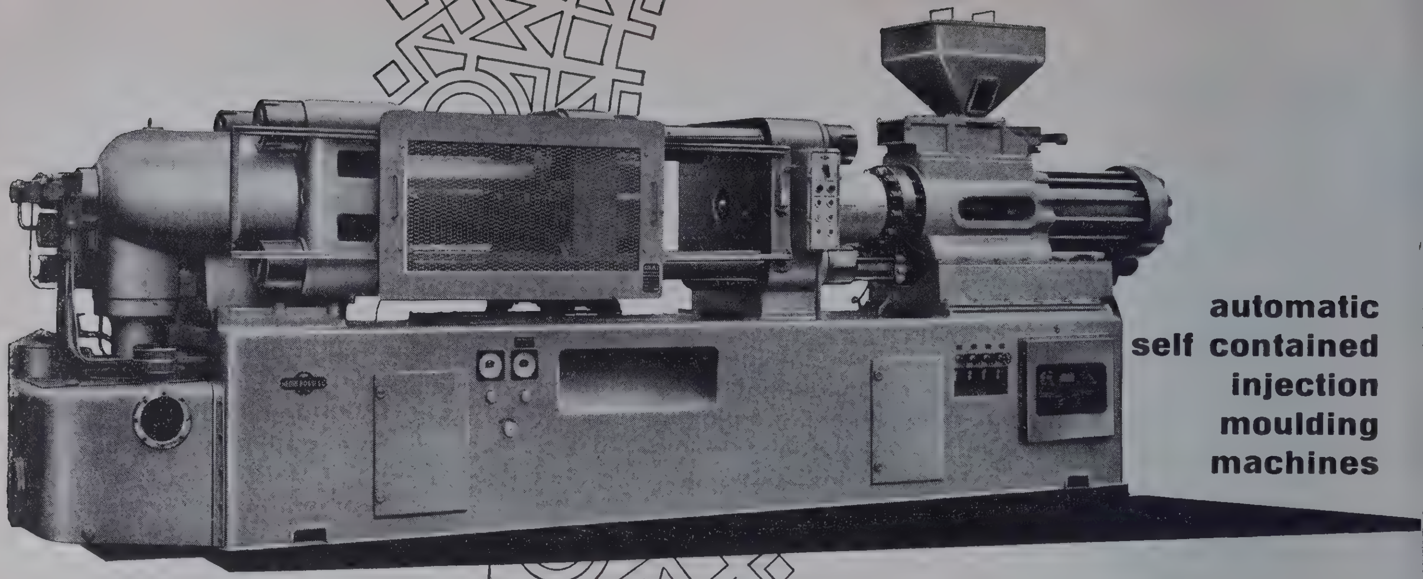
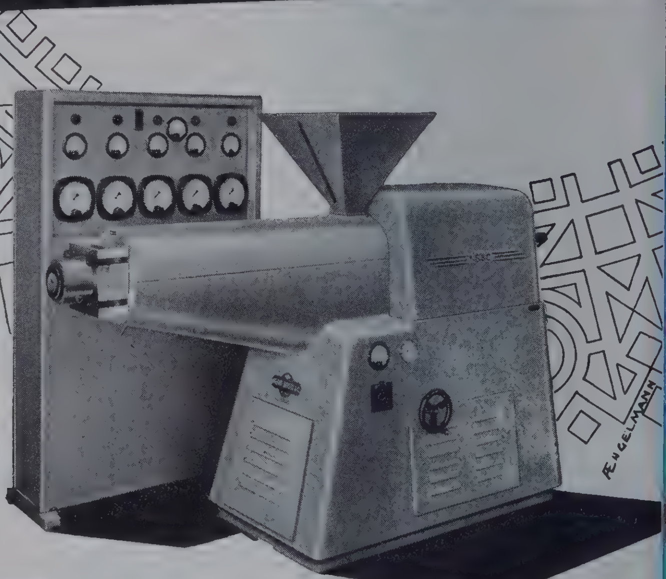


**automatic
self contained
injection
moulding
machines**



extruders and
complete
extruding
equipments

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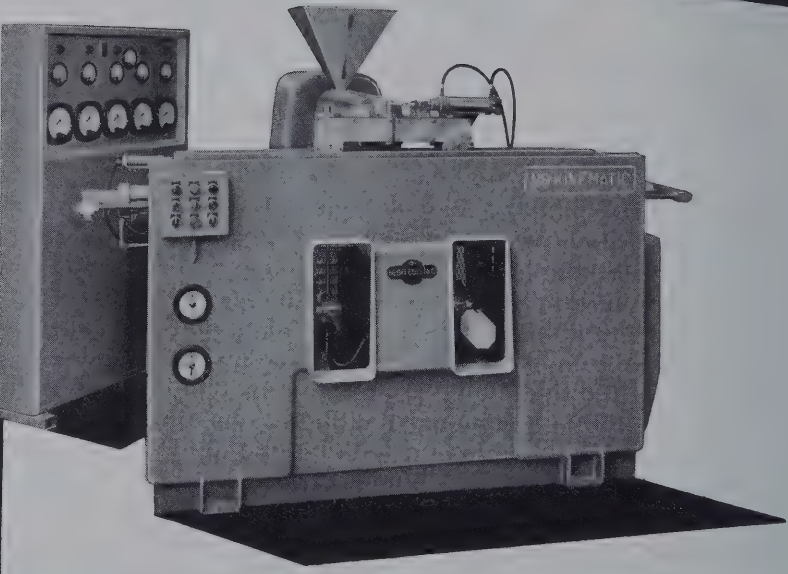
"NB-Kinematic"
blowing machines
for bottles,
toys etc.



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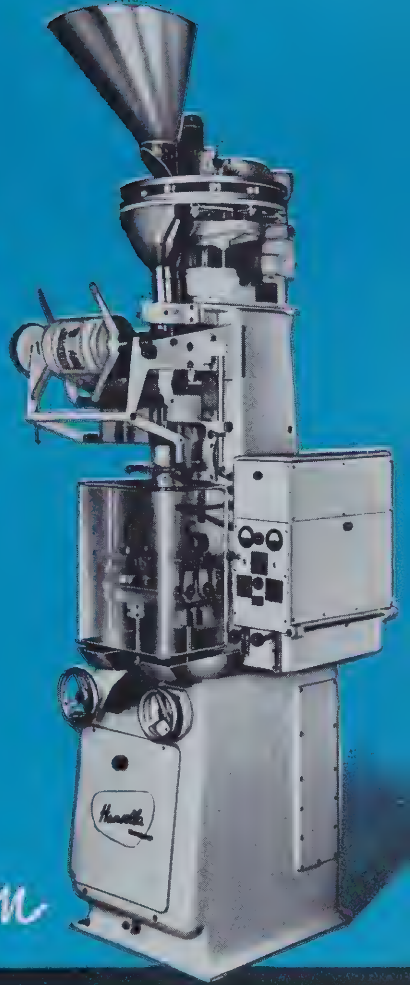
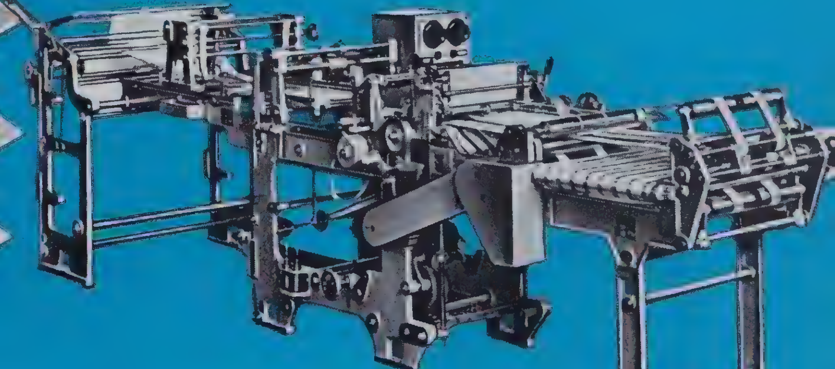


high capacity
easy maintenance
accurate delivery
stronger seams
are some of the main features of the
Polybag-Machine **PRINTEX 380**

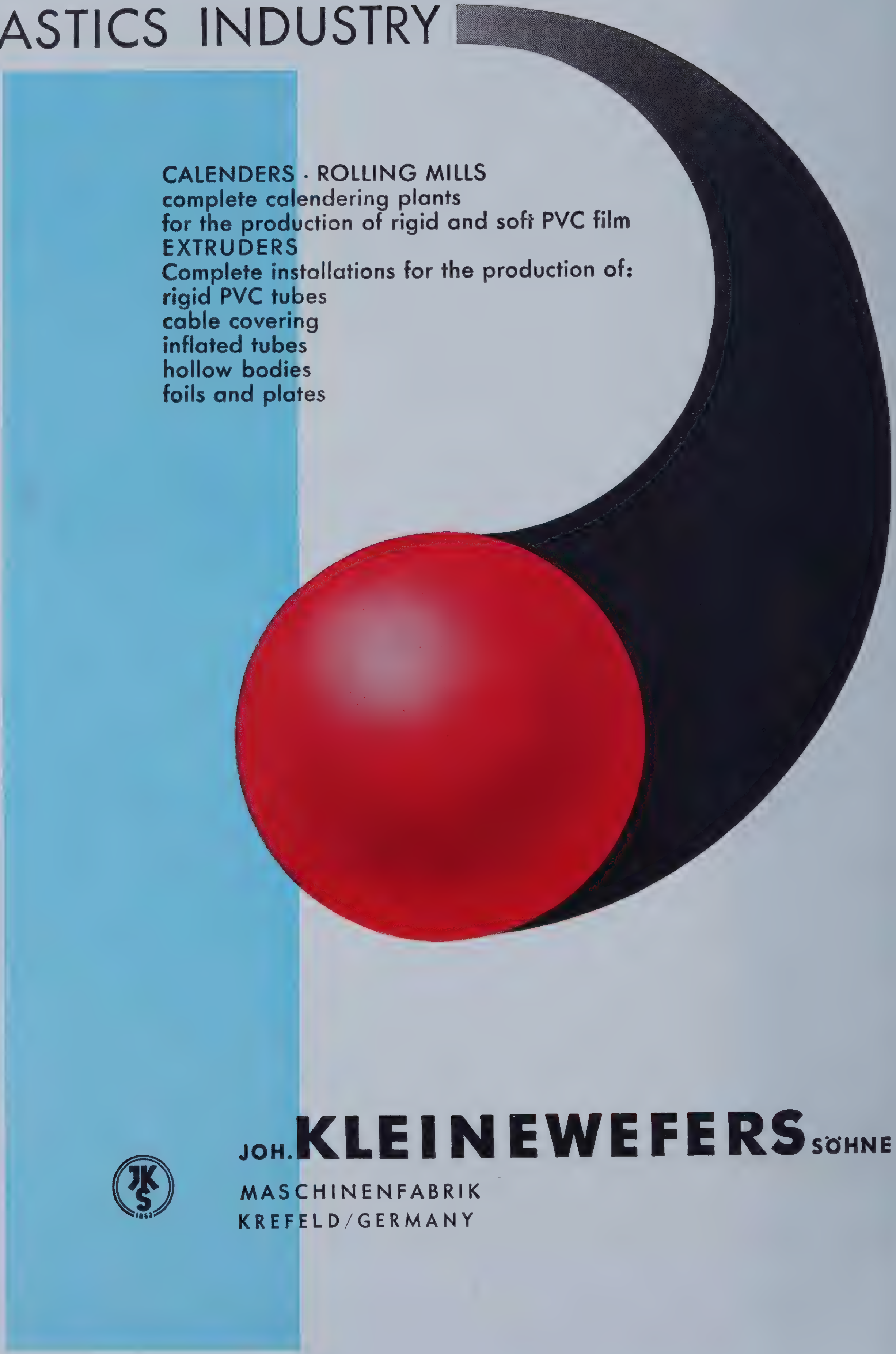


for details and samples

MAC Packmaschinen GmbH, Düsseldorf/Germany

Allee 61 Tel. 10116 Telex 08 582348

HAMAC



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- Expandable Polystyrene - Complete Installations
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  - Mold Holding Presses
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- (In Addition to Scrap Grinders, Material Handling, and Drying Equipment)
  - Injection Machines-2 to 32 oz. Capacity
  - Extruders with Various Take-Off Arrangements
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- Air Compressors
- Magnets for Contamination Control
- Mold Temperature Control
- Oil Purifiers
- Printing Equipment for Molded Items
- Silicone Mold Release
- Surface Pyrometers
- Vacuum Forming Equipment
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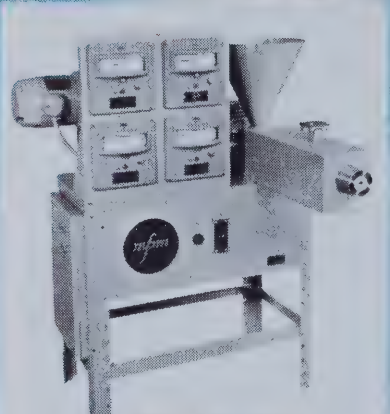
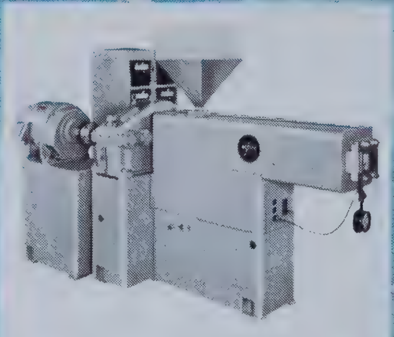
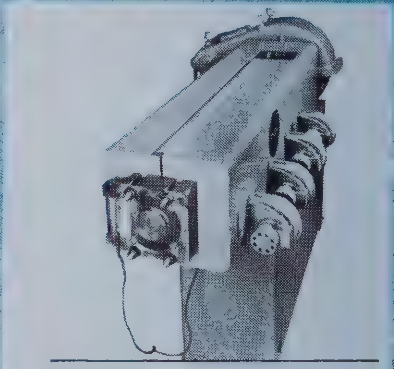


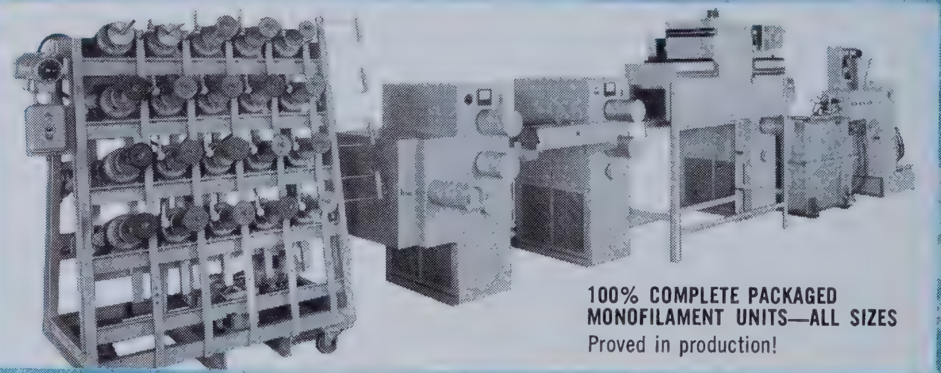
MODEL EVF-100-20
1" VENTED LAB EXTRUDER



MODEL EF-200-20 FOR TEFLON 100X
AIR-COOLED PLASTIC EXTRUDER
With directly coupled 15 H.P. Reliance drive, Z-Nickel Screw and stainless steel lined hopper hole



MODEL ESF-250-20
AIR-COOLED PLASTIC EXTRUDER
(SIDE FEED FOR SCRAP RECLAIMING)
Available in all sizes



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MPM's sensational new "Century Series" Extruders available in Standard, Hi-Speed and Vented models with screw sizes from 1" to 8".

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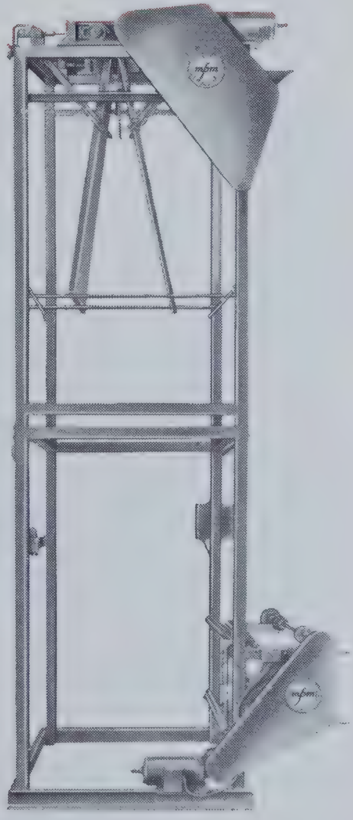
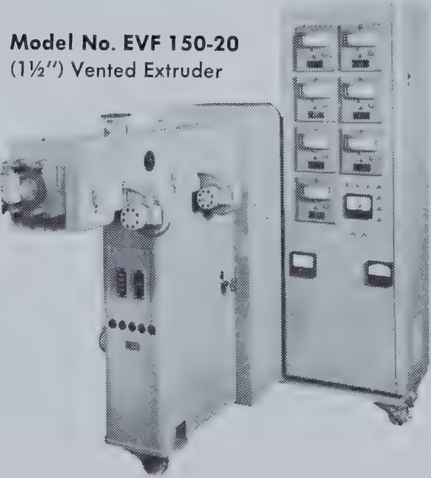


Model No. FWF 36-1
36" Combination overhead forming, pinch roll and center wind takeup for blown tubular film.

Precision Air Rings and Blown Film Dies in all sizes.



Model No. EVF 150-20
(1½") Vented Extruder

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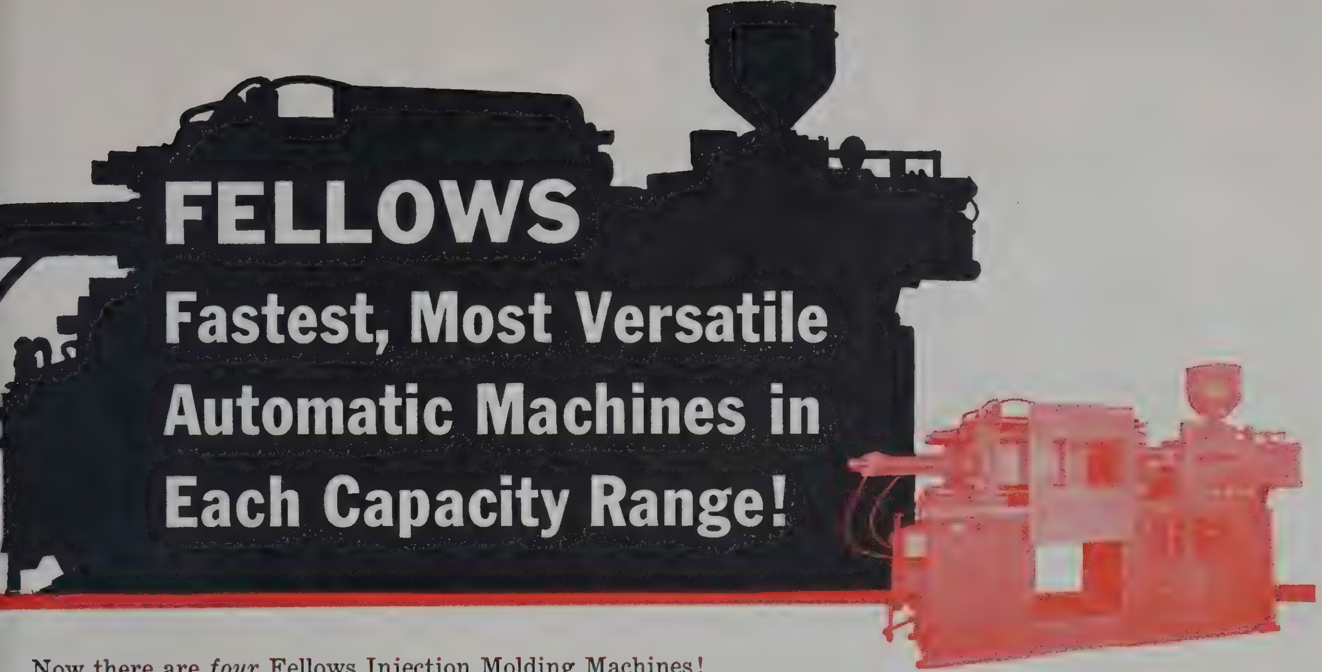
DIE SINKING—MOLD MAKING MACHINERY

Illustration shows how an intaglio design is transferred from an enlarged master to the work piece, on a manually controlled Gorton Pantomill. This is a low-cost, high-quality mold for the cover of a plastic silverware chest. Tracer-controlled Gorton Pantomills, Die and Mold Duplicators, and Die Sinkers, either manually, mechanically or hydraulically operated, or automatically with Auto-Trace 180° automatic tracers . . . all are important in making plastic molds. If no standard Gorton Machine meets your needs, we shall be glad to work with you in custom designing one that will. Complete data on Gorton Pantomills and Duplicators on request.

GEORGE GORTON MACHINE CO., 1320 Racine Street, RACINE, WIS., U. S. A.



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Fastest, Most Versatile Automatic Machines in Each Capacity Range!

Now there are *four* Fellows Injection Molding Machines! In each of three capacity ranges up to 20 ounces, they deliver extra profit through high-speed, reject-free, fully-automatic operation with nearly every resin and on every type of job, whether on high-precision industrial or defense work or on mass-production consumer items.

Sensitive, accurate, built-in controls simplify set-ups as well as production. A wide variety of optional special attachments permit automatic production of products with external and internal threads, undercuts, side cores and many other "hard-to-mold" characteristics.

Get full information about the complete line of Fellows Injection Molding Machines and optional attachments from your Fellows Plastics Specialist. Ask him about the versatile *Fellows Plans*, also: convenient short or long-term financing that lets your machines pay for themselves out of their extra earnings. Write or phone any Fellows office.

and SEQUENTIAL IMPACT MOLDING!

"SIM" increases production speed 30 to 50%, lowers tooling costs, eliminates core shifting, weld lines and warping: melt is pre-compressed and then "fired" at high speed into each cavity or mold in sequence. SIM equipment has been perfected in over four years of development, testing and operation.

MODEL	3-125	6-200	6-10-225*	12-350
Rated Capacity	3-4.5 oz.	6-9 oz.	6-10 oz.	12-20 oz.
Max. Mold Size	12″ x 17″	15″ x 21″	15″ x 25″	20″ x 32″
Mold Locking Force	125 tons	200 tons	225 tons	350 tons
Mold Opens	5″-8″	6″-9″	8″-14″	10″-20″
Dry Cycles per hour	600-840	490-650	825-925	600-800
Horsepower	15	20	20	40
KW Heater Unit	6	12	14	21
Plasticizing lbs. per hour	45	75	100	150

*6-10-225 machine also available with optional 30 HP motor, changing dry run speed to 975-1100 cycles per hour and optional oversize "large-inventory" heating cylinder at extra charge.

Fellows

injection molding equipment

HE FELLOWS GEAR SHAPER COMPANY, Plastics Machine Division, Head Office and Export Department: Springfield, Vermont
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A completely *NEW CONCEPT* in thermoforming of sheet plastics . . . AIR-O-FLOW THERMOFORMING MACHINES are adaptable to innumerable sheet forming methods . .

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. . . production efficiency for heavier gauge thermoplastics. Rapid mold setups . . . ease of operation . . . ideal for short and long run applications.

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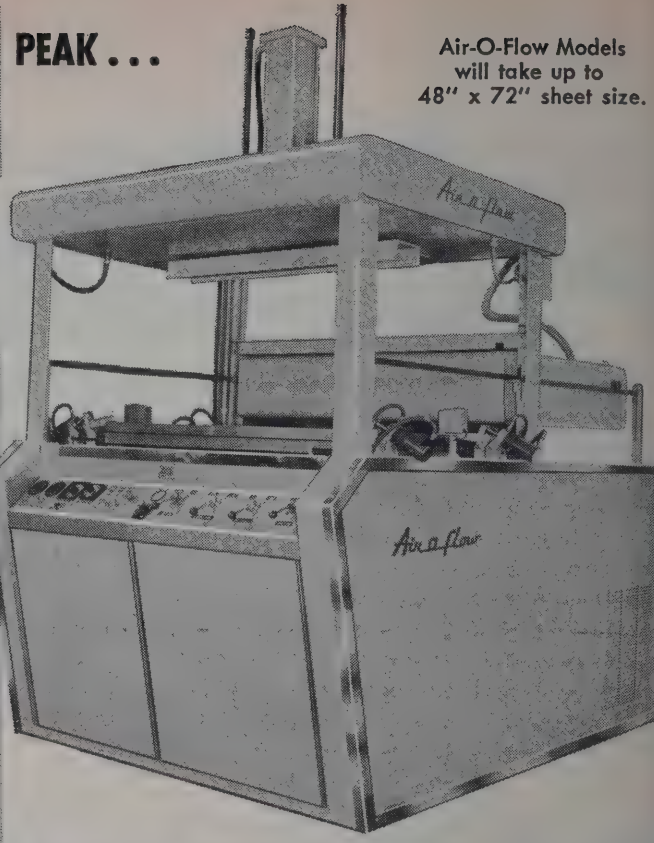
Air-O-Flow Models will take up to 48" x 72" sheet size.



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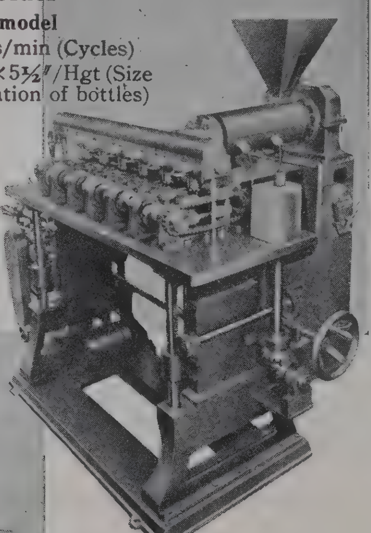
Air-o-flow INDUSTRIES, INC., 74 VARICK STREET, NEW YORK 13, N.Y. • WOrth 6-3832

"KTS" Injection Molder! Extruder! Blow Molder!

Automatic Blow Molder

6-mold model	4-mold model
18-24 pcs/min	8-12 pcs/min (Cycles)
1"/Dia×3½"/Hgt	2"/Dia×5½"/Hgt (Size limitation of bottles)



Upward Inflation Tubular Film Making Unit

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Extruders, 42, 50 & 75 MM
Various Extrusion Dies
Belt & Tube Take-up Attachments
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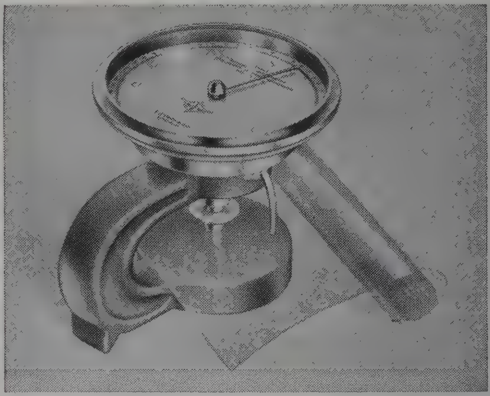

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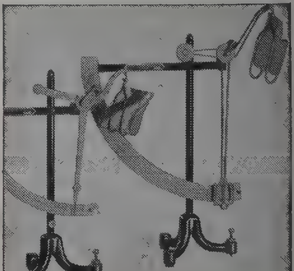

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- FILM DIES
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- TOWER TAKE-OFFS & WINDUPS
- AIR RINGS
- ROLL POLISHING UNITS
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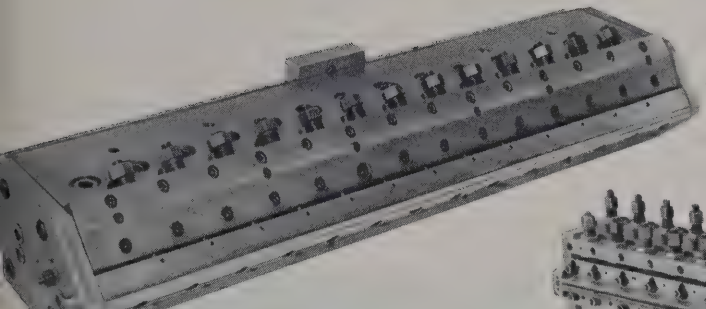
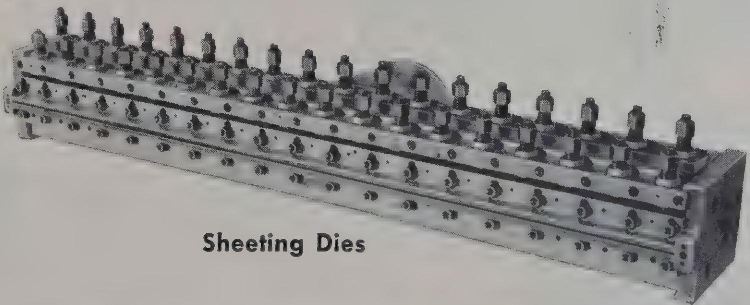
- EDGE TRIMMERS & SLITTERS
- SPECIAL EXTRUSION SCREWS

Every size and type of auxiliary equipment necessary for economical, quality production of extruded plastics is engineered and manufactured by Johnson.
Johnson equipment is regularly employed in conjunction with extruders made by every manufacturer in the field.
Unique experience and specialization *solely* in screws, dies and equipment for making, handling and processing sheet and film extrusions equip us to meet your most exacting requirements.

Johnson will be pleased to quote on your needs and submit suggestions on auxiliary extrusion equipment to meet special situations. Write today.



Flat Film Dies



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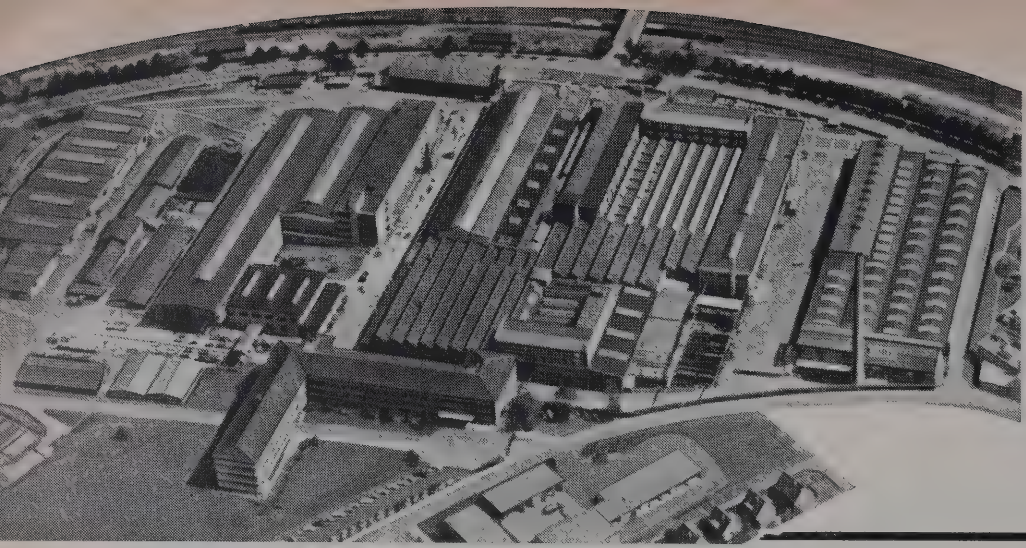
WERNER



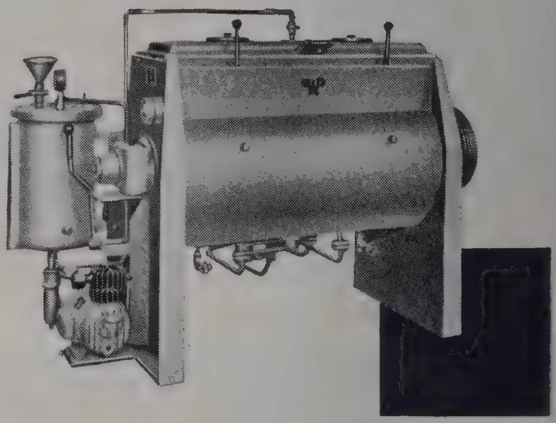
Werner & Pfleiderer of Stuttgart, Germany, ever since they started business in 1879 have been spezialized in the manufacture of mixing equipment.

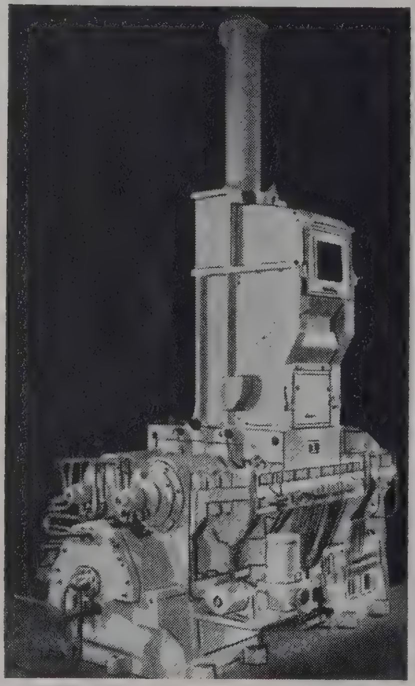
The sigma blade, conventional as it is today, was once invented by Werner & Pfleiderer. The develop-

SIMPLEX MIXERS

for premixing all kinds of plastics in crumb or powder form and hot dry blending PVC

- lathe turned trough for close clearance to avoid sticking of material
- rounded edges for quick and easy clean-out

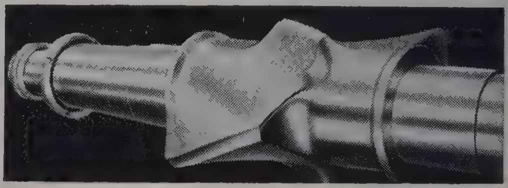




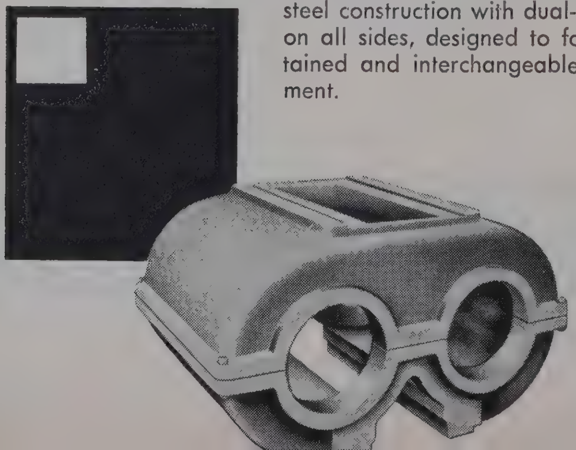
INTERNAL MIXERS TYPE GK

for large scale production of compound and calander feeding

- mechanical strength provided by cast housing with replaceable mixing chamber, self-aligning roller bearings, forged steel shafts with cast rotor bodies shrunk thereon.
- no bull-gear-pinion drive. Either Uni Drive or Semi Uni Drive. The latter provides power transmission to one rotor shaft only, the coupling gears being incorporated in the mixer design.
- hydraulic operation of the sliding discharge door. Drop door is optional feature.
- four-bladed large diameter mixing rotors perform rapid and excellent dispersion, allowing high HP input.



- replaceable mixing chamber of welded steel construction with dual-purpose jacket on all sides, designed to form a self-contained and interchangeable machine element.



- dust-stops between both rotor shafts and mixing chamber consists in spring-loaded floating ring seals with hardfaced contact faces and automatic lubrication.
- roller bearings and special thrust load arrangements eliminate pumping action of rotor shafts.

& PFLEIDERER Serve the world's plastic industry

ment of modern processing machines has now resulted in — besides other lines — a number of special equipment for processing plastics, survey of which is provided by the information below.

Today, 2600 employees contribute their skill to incorporate the traditional WP standards of workmanship and progress in this special line of Werner & Pfleiderer machines.

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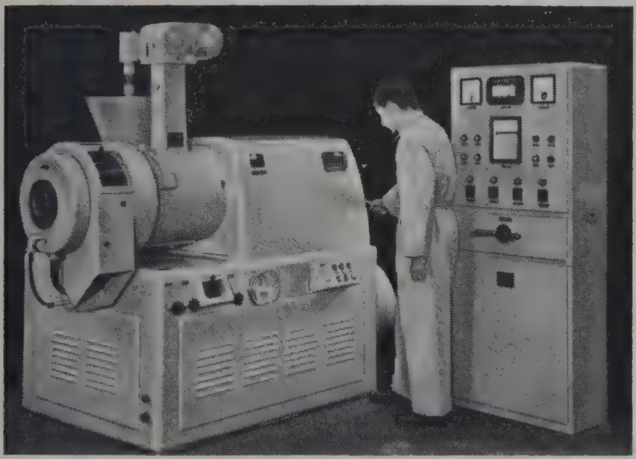


PLASTIFICATOR

Compounder / Pelletizer producing plasticized PVC (5 – 60 parts plasticizer per 100 parts resin) in a continuous process.

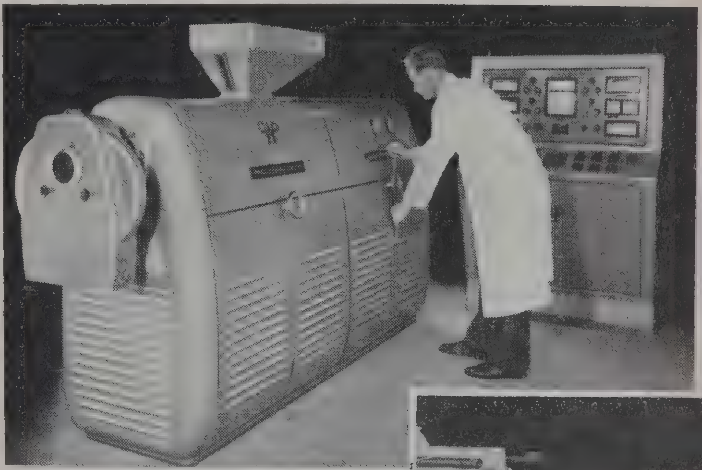
- ▶ output: 200 – 450 lbs, starting from premixed materials
- ▶ gelling of polymer by frictional heat. Therefore heat history reduced (45 secs.) and uniform
- ▶ simple control allows operation by unskilled labor
- ▶ fast clean-out in case of colour change

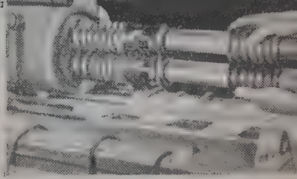
TWIN-SCREW DEVOLATILIZING DISPERSION EXTRUDER TYPE ZSK 83/700

for continuous compound production (pellets), especially when difficult operations are involved such as carbon black dispersion, pigment dispersion, removal of moisture or monomers

direct calander feeding with rigid and plasticised PVC or co-polymers up to 660 lbs per hour

extrusion, starting from cold premixed materials or from pellets





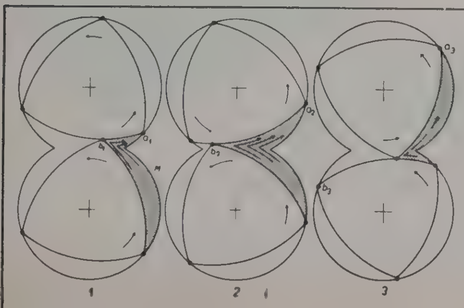
▶ variable screw design:

each screw is composed by a number of bushings, which are fitted on the shafts by a key-way. These bushings consist of threaded sleeves and kneading disks; which can be arranged to give more or less compression, kneading action etc. depending on the product to be processed.

▶ self-cleaning screws:

the treated sleeves have a patented intermeshing close-clearance profile avoiding any sticking of material

optimum mixing and dispersion effect by means of self-cleaning kneading disks of patented design.



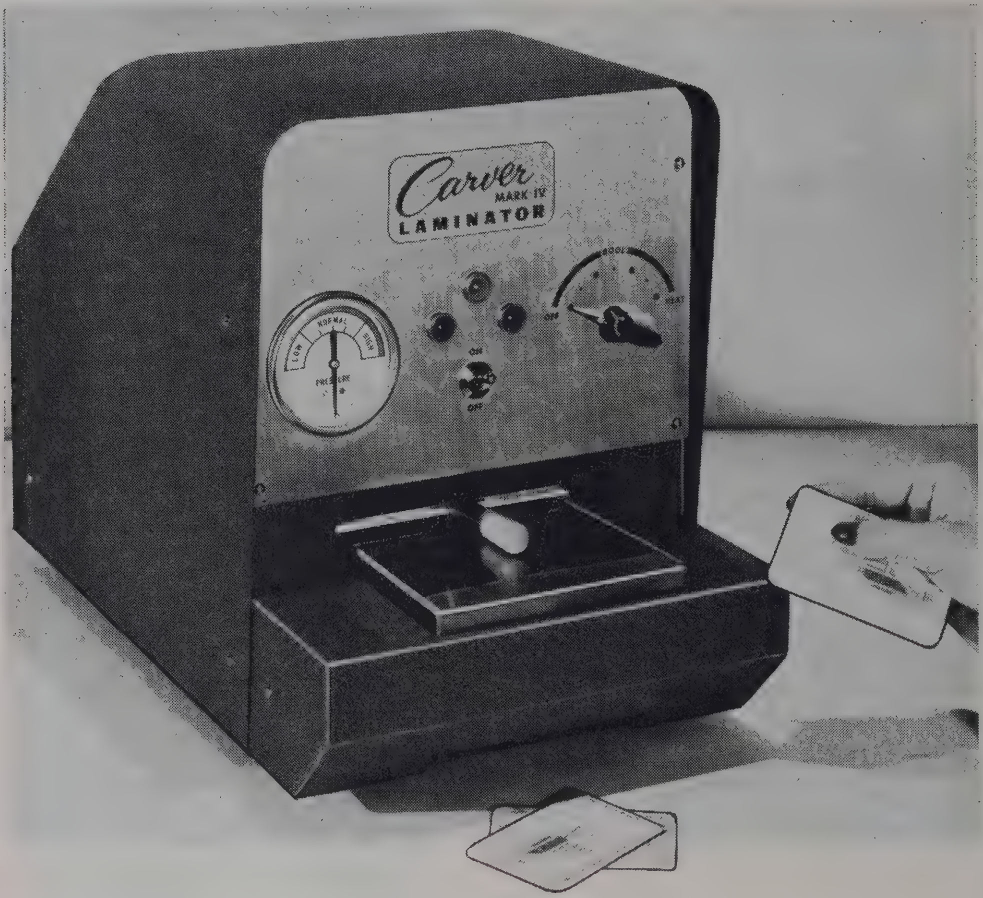
▶ excellent venting and devolatilization:

The self-cleaning twin-screw design offers the best conditions for work under vacuum since no build-up of material in the decompression zones can occur.

▶ extra-strong drive and thrust assembly:

for a machine of this size a 40 HP drive is quite exceptional but the thrust bearings and the power transmission are designed for still higher ratings. This surplus strength is the key to high output figures.

Introduced by FRED S. CARVER INC.



...the new MARK IV PLASTIC LAMINATOR

The modern automated office finds new efficiency and convenience with this attractive, portable, all-new Carver Mark IV Laminator . . . the result of Carver pioneering with small-size laminating equipment.

Features are: Unique compact design; Extreme simplicity and reliability of operation; Self contained unit requires only normal AC electric outlet. Accurate, adjustable electro-hydraulic system is combined with fast radiant heating and triple effect air cooling; laminates either all-plastic or paper-inserts. The Press has single control; processes cards, badges or photographs through automatic cycle. TAMPER-PROOF, MOISTURE-PROOF, LIFE-TIME LAMINATIONS . . . completed singly or in groups of 4 or more, within platen limits of 4″ x 5½″ . . . CAPACITY UP TO 60 WALLET-SIZE CARDS, OR 120 BADGES PER HR. Thermostat control insures complete flexibility of operation.

Press automatically performs full laminating cycle of pressure, heating and cooling; pilot light signals completion. The laminated cards may be trimmed with straight edge photographic trimmer and corner rounder or speedily punched in the Carver Mark IV Die Cutter shown below.

The Carver Laminator is styled in durable crackle finish green cabinet with gold anodized front panel — truly desk-top equipment appropriate to any office decor. Standard model Mark IV Laminator 110 volts AC complete with 6 ft. cord, 2 loading tray assemblies and rear outlet for Die Cutter — $625.

...the MARK IV DIE CUTTER

Designed especially for use with the Mark IV Laminator, this machine trims laminated cards with maximum convenience, accuracy and speed. Hydraulically operated and electrically controlled . . . operates from any standard electric outlet. Provides visual alignment, clean, no-burr cutting. Trims over a hundred cards per hour. Die size 3½″ x 2-5/16″ with ¼″ radius corners. Complete with 6 ft. cord for 110 volts AC use — $325. Send for bulletin.

U. S. and Foreign Patents Issued and Pending

FRED S. CARVER INC.
HYDRAULIC EQUIPMENT
5 CHATHAM ROAD SUMMIT, N. J.

...serving the Plastics Industry for more than 30 years...

CARVER LAMINATING PRESS

Our Standard Production Model . . . for laminating TAMPER-PROOF • MOISTURE-PROOF Identification Cards and Badges, Photographs, Important Papers in sizes up to 9″ x 12″.

The Carver Laminating Press has proved its superiority as a dependable production unit for laminations from wallet size to letter size. It is widely used by many governmental agencies, and by industrial firms, colleges and institutions.

Material to be laminated is placed between two sheets of Vinyl, Acetate, or other suitable plastic, in stacks to six layers within the size of the polished plates. Each stack is electrically heated with accurate thermostatic control and rapidly water cooled.

Model 150 Carver Laminating Press is recommended for all wallet size cards, passes, badges, etc. Two such cards can usually be laminated in each layer or a total of twelve in a stack. Over 800 such pieces can be laminated in a normal day.

Model 154 Carver Laminating Press with 9″ x 12″ plates and blotters can laminate all work up to a maximum of approximately 8½″ x 11½″. Here again six layers are laminated at one time.

The original two opening feature for simultaneous heating and cooling of two stacks assures a continuous flow of work of uniform quality. No special wiring or plumbing required. No particular skill is required and the complete service and instructon manual is furnished with the Press as well as all necessary operating accessories. Prompt shipment from stock. Bulletins sent upon request.

CARVER LABORATORY PRESS

. . . Standard for Plastics Research, Development and Control

In thousands of leading industrial firms, government and technological laboratories the Carver Laboratory Press is an indispensable aid in plastics research and development. Original in design, the Press has long been accepted as standard for making quick, accurate small-scale tests; for development, research and instruction work; testing single cavity molds; preparation of samples, and for small scale production.

The Press is equipped with large easily-read gauge normally having the maximum reading of 24,000 lbs. Lower reading gauges are available. The Press can be supplied with or without Carver accessories: Electric or Steam Hot Plates; Electrically Heated and Water Cooled Hot Plates; Carver Test Cylinder Outfits, 2¼″ ID., or 1⅛″ ID.; Swivel Bearing Plates; Cage Equipment; etc.

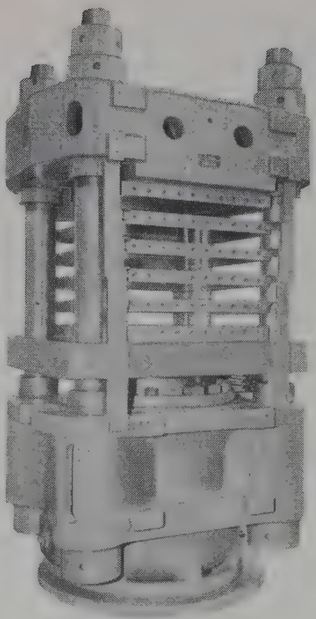
Also available in a larger 20 Ton Model with 8″ x 8″ platens similar to the Standard Press except for size, weight, and capacity. Accessory Hot Plates in the 8″ x 8″ size similar to those available for the Standard Press can be supplied. The Press and certain of the accessories are patented. • Free bulletins available describing Press and some of its many applications.

FRED S. CARVER INC.
HYDRAULIC EQUIPMENT
5 CHATHAM ROAD SUMMIT, N. J.

BOUGHT and SOLD

NEW USED REBUILT

Plastics and Rubber Machinery



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- Presses
- Extruders
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- Vulcanizers

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Reliable specializes in rebuilding all types of plastics and rubber machinery.

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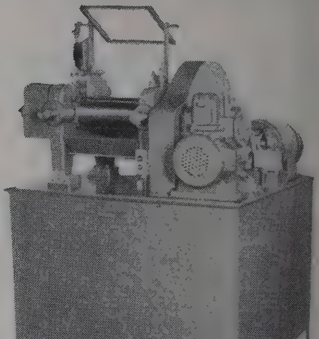

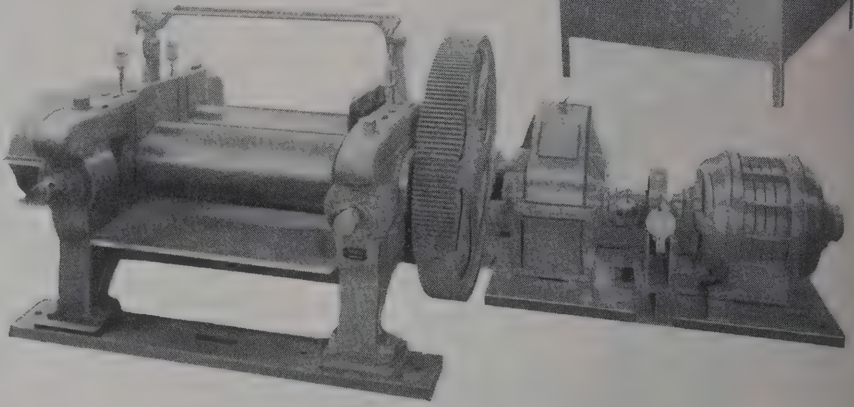

Write, wire or telephone for full information

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BLOW MOULDING-INJECTION MOULDING-EXTRUDING

The latest in engineering developments.
Low temperature applications.
Designed to meet your requirements.
Decrease mould cycle.

A complete, self-contained portable refrigerating unit.
Portable and stationary units—5 to 15 H.P.

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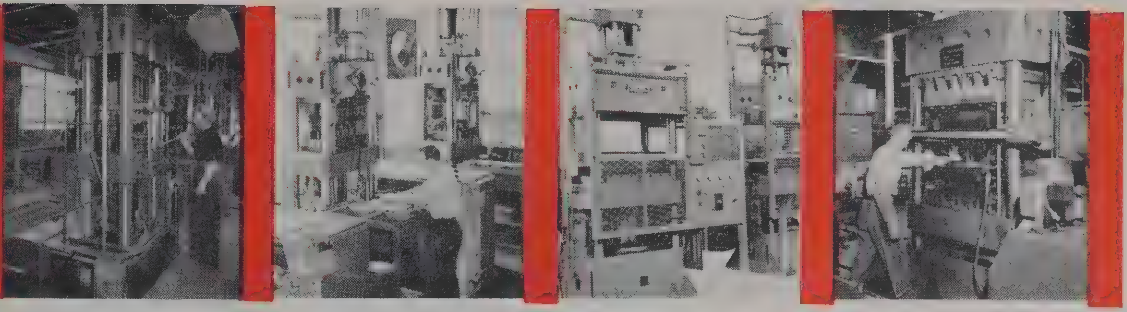
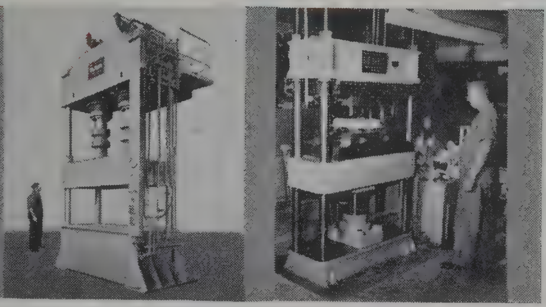
For YOU, too . . .

Elmes can turn pressing problems into profit-making performance!

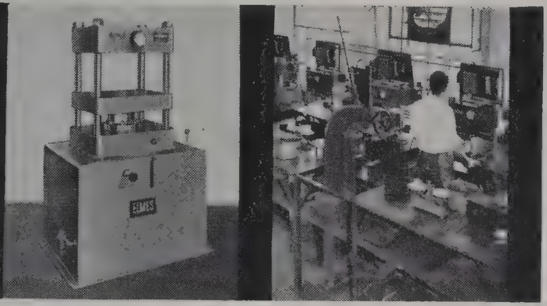
COMPRESSION AND TRANSFER MOLDING



REINFORCED PLASTICS MOLDING



LABORATORY AND SMALL PRODUCTION

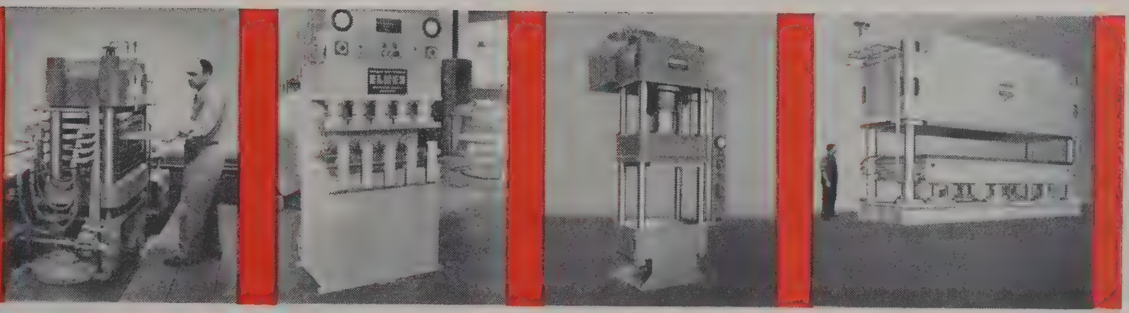


Elmes Engineering vision and know-how have provided hundreds of cost-reducing press installations like these during more than 60 years of leadership in specialized hydraulic service.

In some cases, a standard-design Elmes® Press met all the job needs. In others, simple modifications were made in the basic press design. In still others, a special "custom built" press was developed to meet unusual production requirements. But in every case the press was Elmes "Job-Fitted"—*the right press for the job.*

Elmes experience and ingenuity can bring the same profit-producing transformation into your shop. Talk it over with your Elmes Distributor, or write us direct.

LAMINATING • HOT PLATE MOLDING • COIL MOLDING



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METAL-WORKING PRESSES • PLASTICS MOLDING PRESSES • PUMPS • ACCUMULATORS

THE MOST ADVANCED MACHINE FOR LARGE INJECTIONS AND MASSIVE PRODUCTION

Injection Molding Machines

SELF CONTAINED
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- *power*
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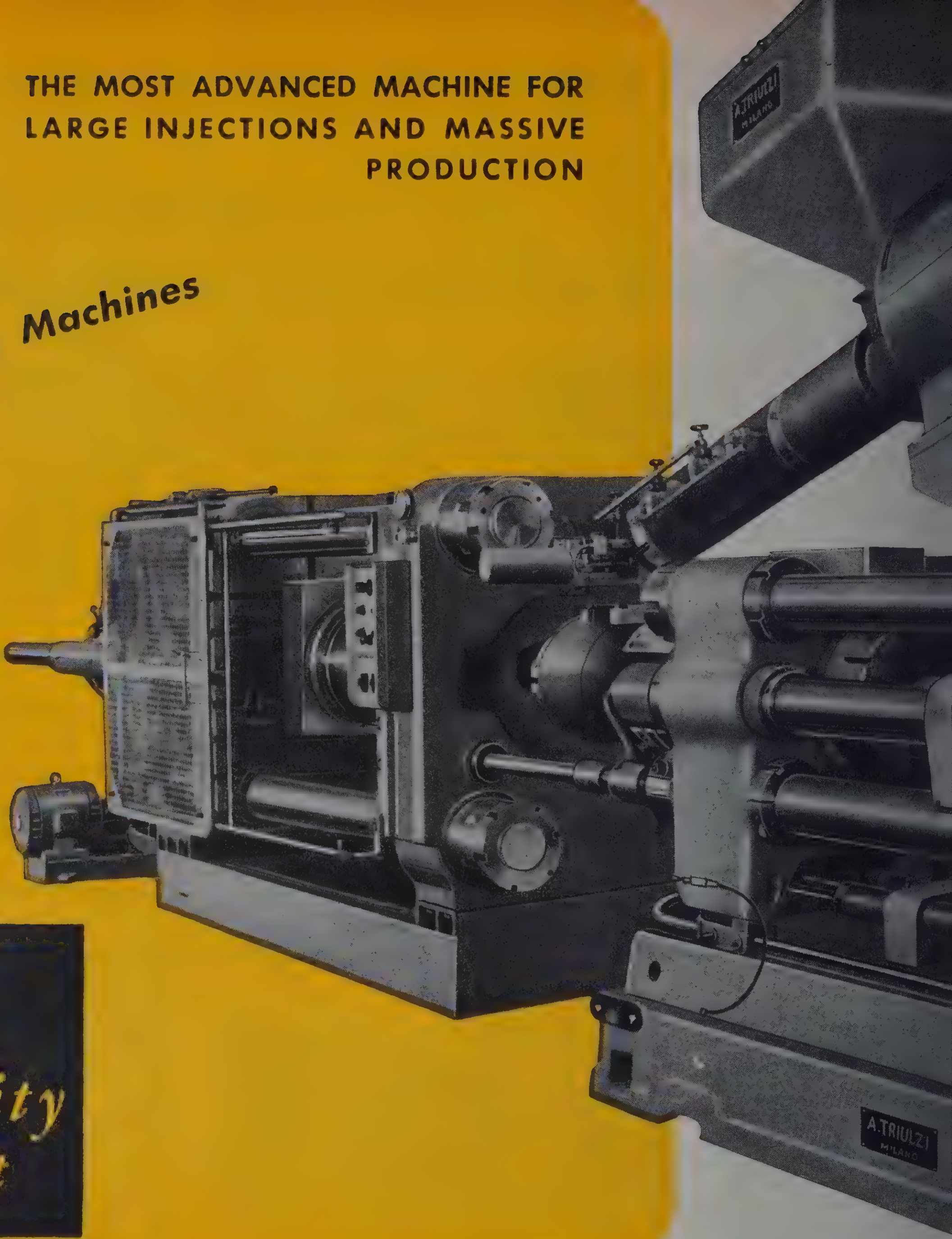
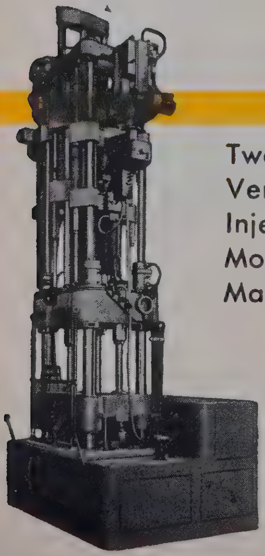
- *output*



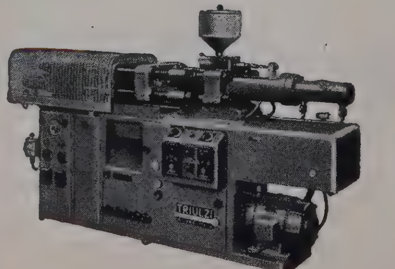
ALL OUR MACHINES CAN BE EQUIPPED WITH PREPLASTICIZER AND PREPACK

Models from ¾ oz. to 700 ozs.

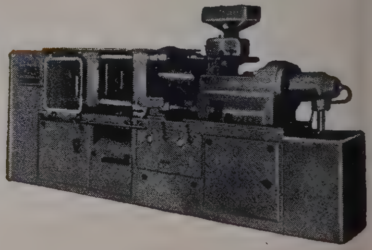


Two-color
Vertical
Injection
Molding
Machine

PLASTMATIC 30/4 tie-bars
1 oz. capacity



PLASTMATIC 200
7 ozs. capacity



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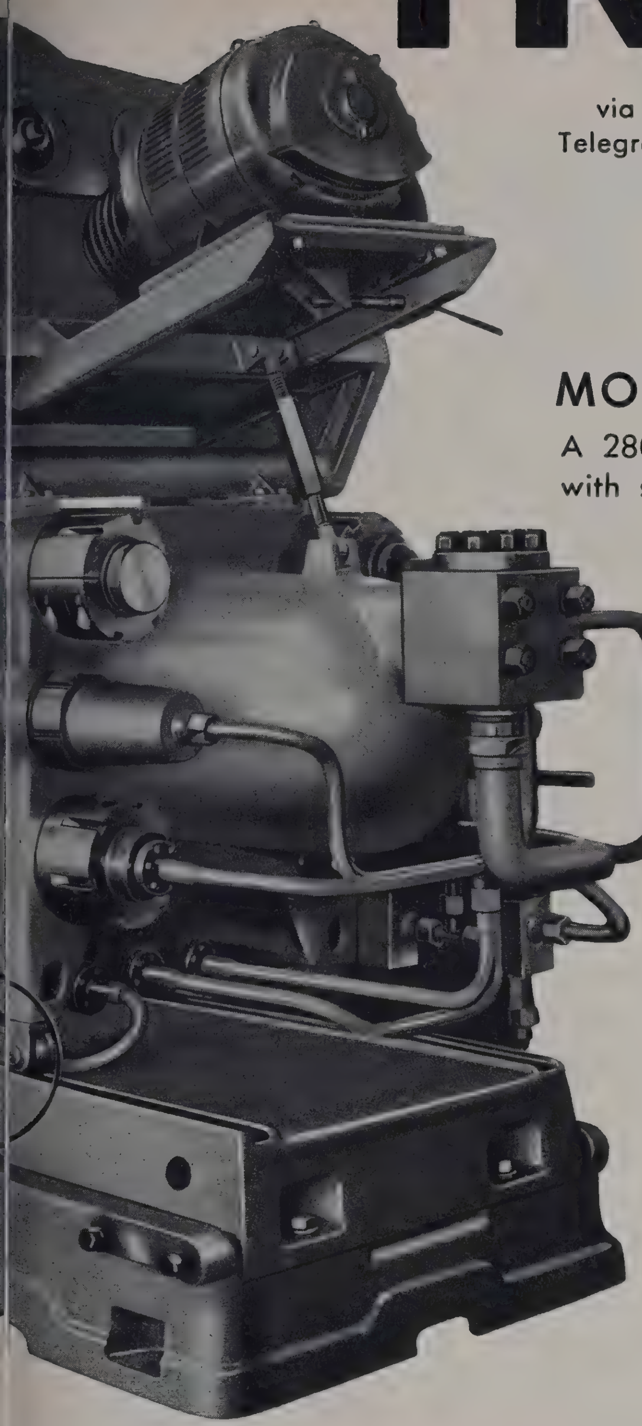
Telegrams: TRIULZIPRES-NOVATE MILANESE



MOD. 600/P120

A 280 ozs. machine
with screw preplasticizer

PLASTMATIC 80/P80
A 50 ozs. machine
with screw preplasticizer

in piston
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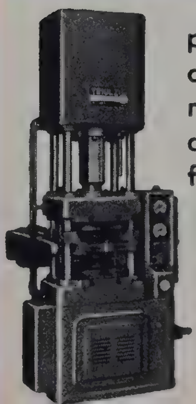
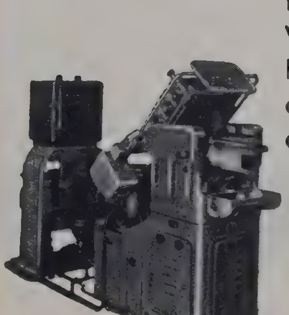
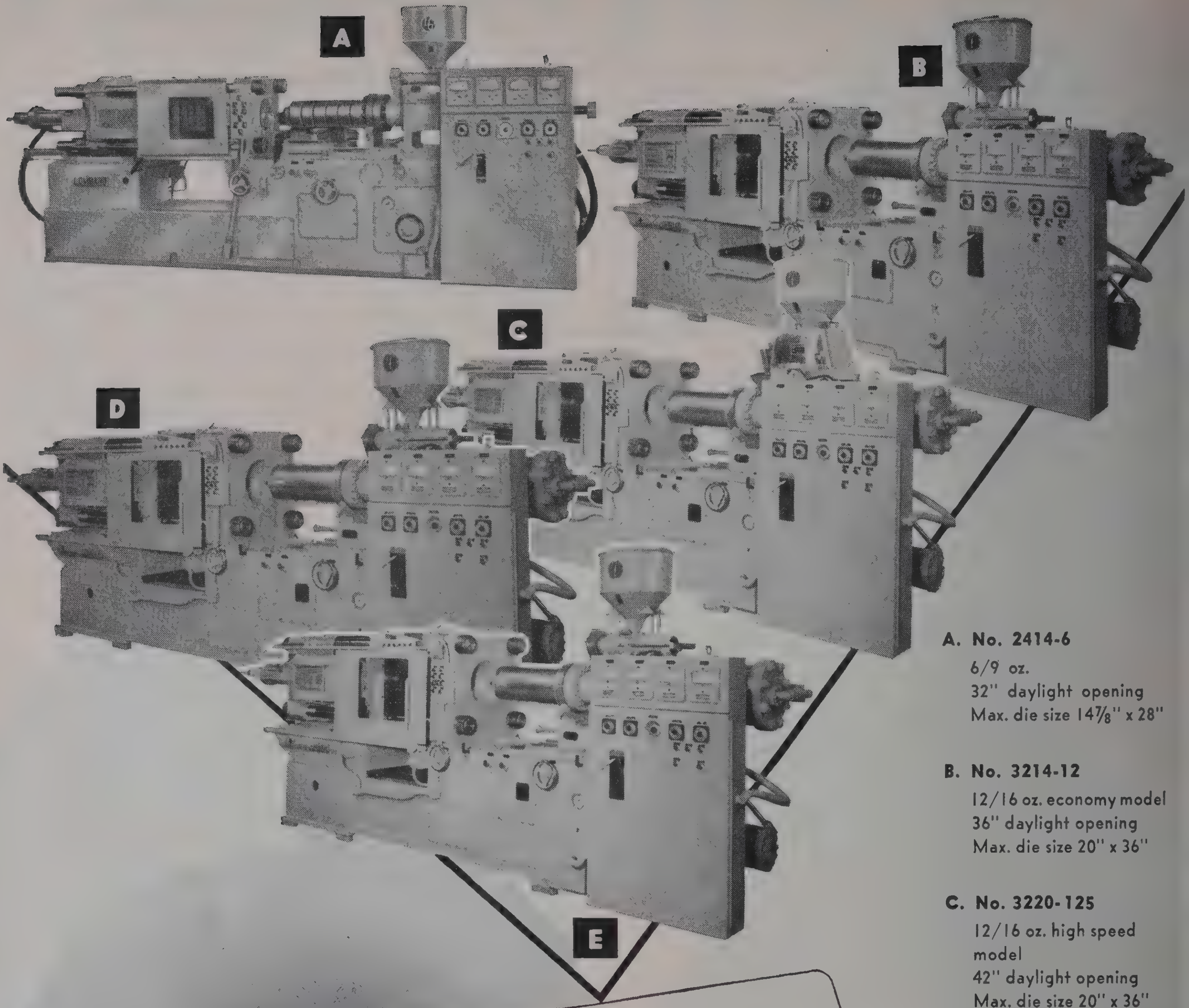
lyesters



"MOLDMATIC"
press with
automatic
metering
device and
filler. 60T.



Automatic
record press
Water
hydraulic
or oil
operated



A. No. 2414-6
6/9 oz.
32" daylight opening
Max. die size 14⅞" x 28"

B. No. 3214-12
12/16 oz. economy model
36" daylight opening
Max. die size 20" x 36"

C. No. 3220-125
12/16 oz. high speed model
42" daylight opening
Max. die size 20" x 36"

D. No. 3220-16
16/20 oz. model
42" daylight opening
Max. die size 20" x 36"

E. No. 3624-18
18/24 oz. model
50" daylight opening
Max. die size 23¾" x 38"

Way out ahead

LOMBARD INJECTION MOLDERS incorporate refinements beyond the expectations of today's or even tomorrow's demands — —

Also available for all Lombard Injection Molders . . .
Revolutionary ***HYDRA-PAK***

99% faster than any standard machine — 17% faster than any special

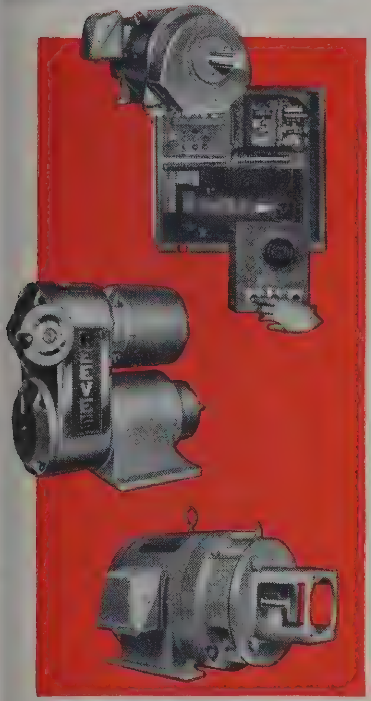
SEND FOR COMPLETE CATALOG.

LOMBARD GOVERNOR CORPORATION
Injection Molding Machine Division
Ashland, Massachusetts

YOUR RELIANCE POWER SELECTOR

MOTORS and DRIVES For Plastic Forming Machines

EXTRUDER DRIVES



V★S EXTRUDER DRIVE—1 thru 350 hp.

All electric variable speed drive operates from a-c. circuits. Standard speed ranges as great as 16 to 1, with constant horsepower available. Wider ranges for special applications.

The V★S system provides soft starts with *full* torque available at low speeds, and controlled acceleration.

Only the drive motor need be mounted on the extruder. All control equipment including operator's panel can be placed in any convenient location, in a new Super 'T' V★S cabinet which is up to 35% smaller. V★S Extruder Drives can be equipped with controls to coordinate extruders with conveyors capstans, or other auxiliary equipment, or for automatic control of extruder output.

For full details, ask for Bulletin No. D-2506.

REEVES EXTRUDER DRIVES—5 thru 40 hp.

Low cost, mechanical variable speed motodrive operates from a-c. circuits. Available in speed ranges up to 8:1.

Reeves Extruder Drives are variable pitch pulley devices powered by standard a-c. motors. A simple turn of a hand wheel selects any speed in the drive range. Pneumatic controls are available for remote or automatic operations.

Low cost Reeves Extruder Drives are simple to maintain. Complete drive mounted right on the extruder, with no additional control equipment required.

For full details, ask for Catalog No. M-592.

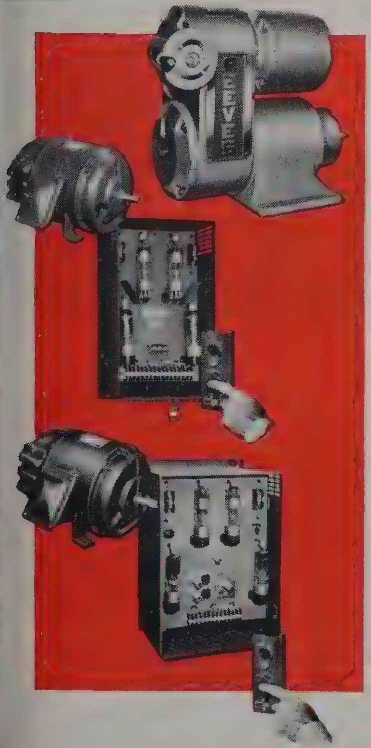
INJECTION MOLDING MOTORS

RELIANCE HYDRAULIC PUMP MOTORS—1 thru 200 hp.

Complete line of a-c. motors designed for powering injection molding machine hydraulic systems. Available for either separate coupled shaft mounting or flange mounting as an integral part of the pump. Drip-proof; explosion-proof; dust-tight.

For full details, ask for Bulletin No. B-2104.

Winders, Pelletizers, Laminators and other auxiliary equipment drives



REEVES MOTODRIVES—¼ thru 5 hp. and up

Low cost mechanical variable speed drive similar to the extruder drive except lower horsepower. Available with speed ranges as wide as 10:1.

Reeves Motodrives furnish any operating speed in their range with a turn of the hand wheel. Simple operation and maintenance. Can be supplied with reduction gears.

For further information, ask for Catalog No. M-571.

V★S Jr. DRIVES—⅛ thru 4 hp.

An electronic variable speed drive, operating from a-c. circuits, the V★S Jr. is similar in principle to the V★S Extruder Drive.

The V★S Jr. has a nominal 8 to 1 speed range, but provides up to a 20 to 1 range when lowest speeds are used for intermittent or light duty. Simple, accurate speed regulation and selection.

Minimum maintenance required, simplified with building block components.

For further information, ask for Bulletin No. D-2507.

VS-100 DRIVE—¾ thru 4 hp.

The VS-100 is an electronic variable speed drive similar to the V★S Jr. Offers a wider operating speed range, providing full running power over a 100 to 1 range. The VS-100 provides excellent speed regulation. The VS-100 is also available as a winder drive which can offer constant torque winding, tapered tension winding or constant tension winding—with a simple adjustment. Stalled tension and speed limit also available. This drive is ideal for center shaft winding applications.

For full details, ask for Bulletin No. D-2501.

WHY YOU SHOULD SPECIFY RELIANCE

Reliance has a nationwide sales and service organization in 65 major industrial centers. This organization is backed up by distribution and warehouse centers in Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Newark, Houston, Los Angeles, Minneapolis, Philadelphia, Portland, San Francisco, Seattle, Shreveport and St. Louis. You can get any standard Reliance, Reeves or Master product directly from these centers. Immediate delivery and service.

D-1631

RELIANCE ELECTRIC AND ENGINEERING CO.

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Canadian Division: Toronto, Ontario
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MASTER REEVES R

FOR OUTSTANDING PERFORMANCE

PRODEX EXTRUDERS

TYPICAL PRODUCTION RATES

SCREW DIAMETER	1¾"		2½"		3½"		4½"		6"		8"	
L/D RATIO	20:1	24:1 VENTED	20:1	24:1 VENTED	20:1	24:1 VENTED	20:1	24:1 VENTED	20:1	24:1 VENTED	20:1	24:1 VENTED
OUTPUT RATES @ 2,000 PSI LBS/HR												
→ PLASTICIZED PVC*	90	100	200	230	370	390	575	630	1100	1200	1900	2000
→ POLYETHYLENE M.I. 4.0†	70	75	170	190	350	375	540	560	1000	1100	1700	1800
→ HIGH IMPACT POLYSTYRENE‡	90	100	200	230	370	390	575	630	1100	1200	1900	2000
STANDARD MOTOR H.P.	7½		20		40		60		125		200	

*PVC Resin, high molecular weight. Resin: 100 parts, DOP: 50 parts, properly lubricated and stabilized. Stock temperature: 400°F.

†Polyethylene, molecular weight: 20,000, melt index: 4.0, density: 0.92. Stock temperature: 420°F.

‡High Impact Polystyrene, commercial grade such as Bakelite TGDB 5001, Dow 475, Lustrex 88. Stock temperature: 430°F.

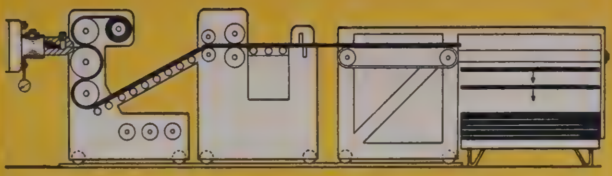
The outstanding performance of PRODEX EXTRUDERS is widely acknowledged . . . in installations both here and abroad. It is based on more than a quarter century of pioneering extrusion experience . . . soundly applied and engineered into rugged extruders featuring the most advanced developments in extrusion technology.

PRODEX EXTRUDERS and complete EXTRUSION SYSTEMS make more profitable operations possible . . . under the most competitive conditions. Higher outputs, faster start-ups, better uniformity, closer tolerances and less maintenance requirements are plant-proven facts.

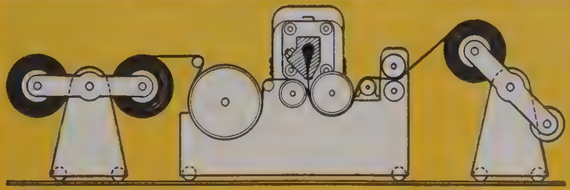
PRODEX offers **vented or non-vented extruders with valving . . . in sizes from 1¾" through 8" with L/D ratios of 20:1—24:1 and longer.** All feature **higher screw speeds** and **higher horsepower efficiency**

PRODEX CORPORATION
FORDS, NEW JERSEY • Phone HILLCREST 2-2800
IN CANADA: Barnett J. Danson & Associates, Ltd., 1912 Avenue Road, Toronto 12

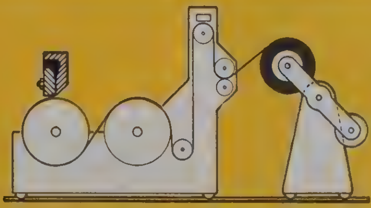
PRODEX
—in design and performance
ALWAYS A YEAR AHEAD



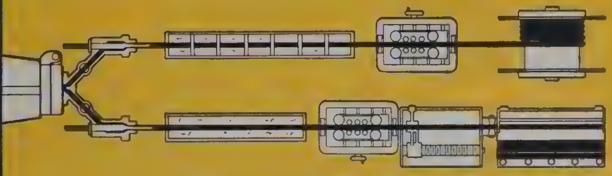
SHEET EXTRUSION



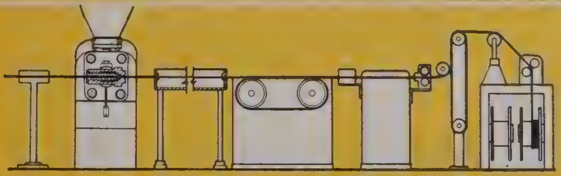
EXTRUSION COATING



ROLL CAST FILM



PIPE . . . MULTIPLE HEADS



WIRE COATING

OMPLETE
XTRUSION
SYSTEMS

PRODEX

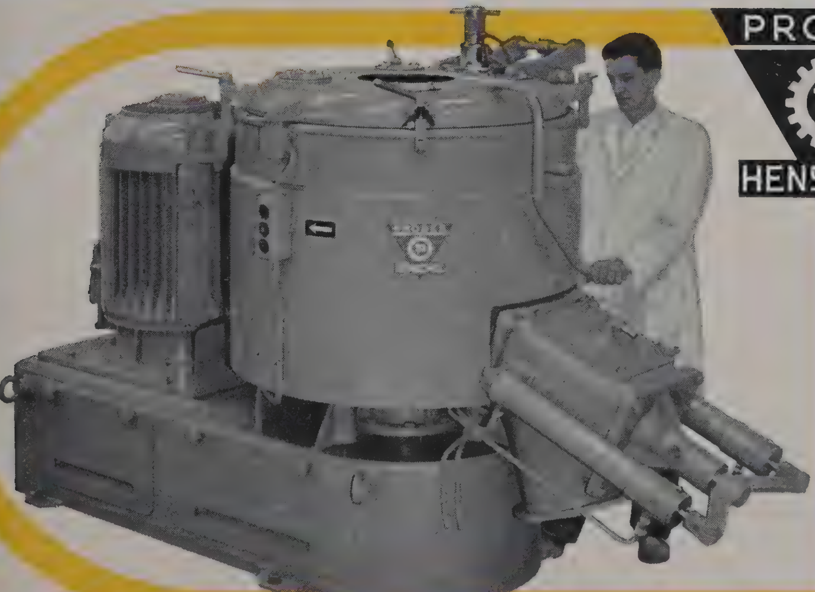
DEMONSTRATIONS

If you're contemplating the purchase of a new extruder or a fully integrated extrusion system, a trip to our NEW TECHNICAL SERVICE CENTER at Fords, N. J. can make a big difference.

Here we'll show you what PRODEX features such as **longer L/D ratios . . . vent and valve . . . higher screw speeds** and **higher horsepower efficiency** can really do with your material.

Here, too, we'll demonstrate the remarkable new PRODEX-HENSCHEL MIXERS, for preparing quality compounds at speeds heretofore not obtained. Of this you can be sure, your visit will pave the way to higher output rates, better products at lower cost.

Write or wire PRODEX CORPORATION, Fords, N. J. or phone Hillcrest 2-2800, and make an appointment for a demonstration.



PRODEX
HENSCHEL
MIXERS

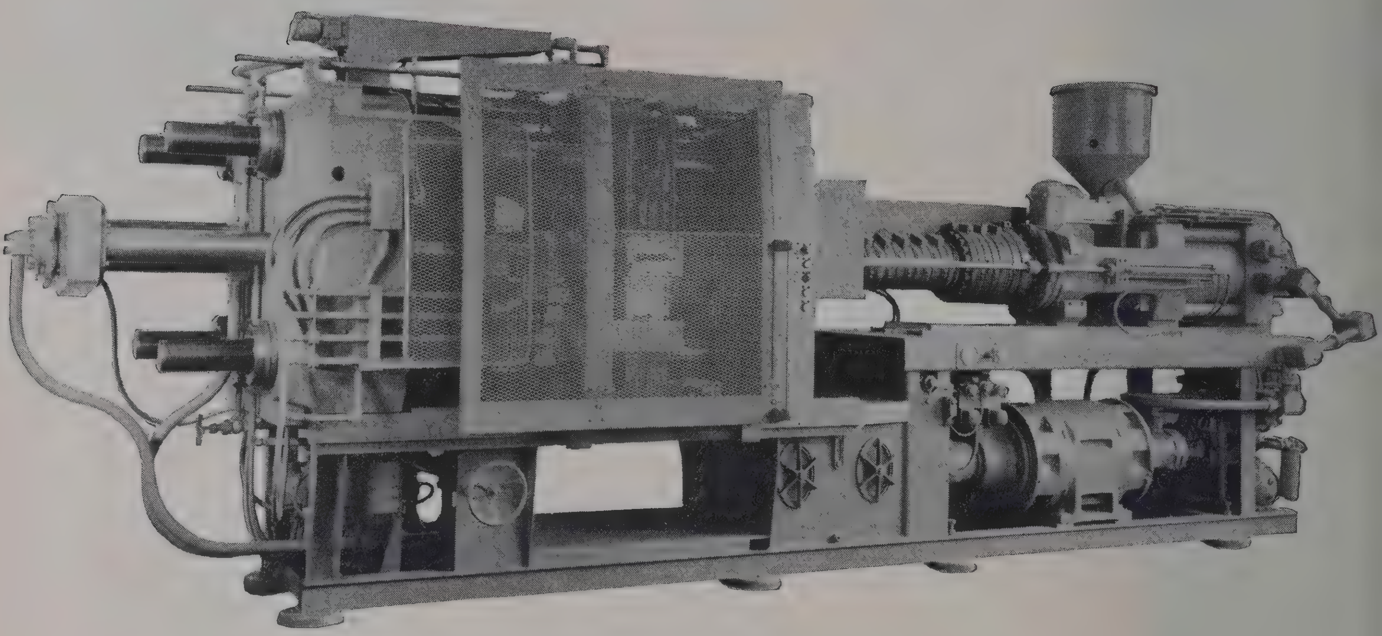
The PRODEX-HENSCHEL MIXER, successfully used in many installations here and abroad, performs intensive dryblending and . . . thorough dispersion of colors, pigments, fillers, stabilizers and/or plasticizers with plastic powders or granules.

It permits the mechanical (frictional) heat-up of plastic powders faster and more uniformly than by conduction or radiation.

The unique principle of fluidizing dry powders so that they can be mixed like liquids, plus controlled shearing action, result in mixing quality and speeds heretofore not obtained.

Announcing A NEW "IMPCO"

Injection Molding's Most Versatile Performer!



Impco Model HA16–425

20 ounce injection molding machine

The size of the new HA16-425 "Impco", combined with its speed and adaptability, make it Injection Molding's most versatile performer! Seven hundred and twenty dry cycles per hour at full 24½ inch stroke — two hundred pounds per hour plasticizing capacity — hydraulic knockout — live adjustments, are but a few of the many features contained in this machine. Let us show it to you.

IMPCO®

**IMPROVED
MACHINERY INC.
NASHUA, NEW HAMPSHIRE**

In Canada, Sherbrooke Machineries Limited, Sherbrooke, Quebec

Export Distributors: Omni Products Corp., 460 Fourth Avenue, New York, New York

Free Product Literature

WHAT IT IS—HOW IT HELPS YOU

THIS SECTION is a review, essentially, of the free product literature which has been offered in issues of MODERN PLASTICS from September, 1958, through July, 1959. It includes as well, an appreciable number of new listings not previously published. The hundreds of pieces of literature listed here have been prepared, and are made available through the Encyclopedia Issue, by the companies who supply the basic materials, chemicals, equipment and services necessary to the production of plastics products.

Through use of these booklets, brochures, catalogs, and technical bulletins, you can conveniently supplement the information contained in the Encyclopedia Issue itself.

HOW TO GET IT

Just turn to the Reader Service Card Page at the end of this section, fill in the information . . . and mail.

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Laminates and Reinforced Plastics 1068
Custom Services 1069
Machinery, Equipment and Supplies 1069

Resins and Molding Compounds, Foamed Plastics

COATINGS FOR PLASTICS. Technical catalog describes a universal spray finish for thermoplastics, a color concentrate for screening and roller coating thermoplastics, coatings for tripolymer and vinyl, special coatings and effects for epoxy, etc. The Bee Chemical Co. (A-1)

POLYSTYRENES. 24-page illustrated bulletin discusses lines of normal and modified polystyrenes. Describes applications, properties, design considerations, fabricating techniques, and finishing operations. Plastics Div., Koppers Co., Inc. (A-2)

INJECTION MOLDING POWDERS. 8-page illustrated brochure lists applications, features, properties, and fabricating data for one cellulose acetate and two polystyrene molding powders. BX Plastics, Ltd. (A-3)

POTTING COMPOUND. Technical sheet describes a polyester coating and potting compound, said to cost less than epoxies and to considerably reduce cure time. Naugatuck Chemical Div., U. S. Rubber. (A-4)

POLYETHYLENE RESIN. 56-page manual discusses the properties, uses, injection molding and extrusion techniques, and fabricating operations involved in the manufacture of products from "Alathon" polyethylene resin. Polychemicals Dept., du Pont de Nemours & Co., Inc. (A-5)

PHENOLIC RESINS, VARNISHES, MOLDING POWDERS. 8-page catalog describes product features, special properties, applications, etc. of lines of available phenolic molding powders, laminating varnishes, foundry resins, coating resins, and industrial resins, and varnishes. Chemical Materials Dept., General Electric Co. (A-6)

SILICONES GUIDE. 16-page catalog describes over 150 commercially available silicone products, including many introduced within this past year. Contains detailed charts, tables, graphs and data on properties and performance, along with illustrated examples of how silicones can cut costs, simplify design. Dow Corning Corp. (A-7)

REINFORCED PHENOLIC, MELAMINE MOLDING COMPOUNDS. 4-page illustrated brochure describes properties of this company's lines of reinforced molding compounds for use in the manufacture of automotive timing gears, electric drill housings, aqua lung housings, etc. The Fiberite Corp. (A-8)

NYLON RESINS. Illustrated 56-page booklet discusses the properties, design possibilities, applications, and advantages of "Zytel" nylon resins. Includes injection molding, extrusion, and wire coating techniques. E. I. du Pont de Nemours & Co., Inc. (A-9)

REINFORCED MOLDING COMPOUNDS. Illustrated folder gives price data for lines of styrene and nylon reinforced injection molding compounds. Includes color, shipping, delivery information. Fiberfil, Inc. (A-10)

POLYETHYLENE RESIN. 8-page bulletin describes a low molecular weight polyethylene resin, which, because of a low melt viscosity and retention of tensile and chemical properties, could be used as a polyethylene hot melt in the roll coating of paper for packaging. Eastman Chem. Prod., Inc. (A-11)

ACRYLIC APPLICATIONS. 16-page illustrated booklet analyzes the product design possibilities of Lucite acrylic resins. Detailed table of properties is included. E. I. du Pont de Nemours & Co., Inc. (A-12)

PHENOLIC MOLDING POWDERS. Illustrated 6-page brochure presents characteristics, powder and molded properties of a line of heat-resistant phenolic molding powders. For cooking and heating appliance parts, connectors, switchgear, etc. General Electric. (A-13)

FOAMED PLASTICS. Illustrated 8-page bulletin describes a line of gas-expanded, foamed-in-place thermosetting plastics. Thermal insulation, reinforcing, potting, electronic transmission and vibration control applications. Nopco Chemical Co. (A-14)

PVC MOLDING COMPOUNDS. Illustrated 12-page booklet describes properties, conversion, application methods, uses of "Chem-o-sol" liquid coating and molding compounds. Predicts new "Chem-o-sol" uses; presents services. Chemical Products Corp. (A-15)

HIGH DENSITY POLYETHYLENE. 16-page booklet describes "Grex" polyethylene resin. Discusses chemical and temperature resistance. Also includes discussion of polymer chemistry. Polymer Chemicals Division, W. R. Grace & Co. (A-16)

GUIDE TO POLYETHYLENE MOLDING. 8-page manual gives detailed recommendations for designing and molding parts of high-density polyethylene. Includes data on mold design, cylinder and mold temperatures, shrinkage. W. R. Grace & Co. (A-17)

FLEXIBLE URETHANE FOAM RESINS. Technical bulletins describe polyester resins derived from polymerized fatty acids, and designed for use in the production of flexible urethane foams. Witco Chemical Co. (A-18)

MOLDING AND EXTRUDING RESIN. 8-page folder pictures and describes properties and applications of a high-impact thermoplastic resin, and its advantages to molders, extruders, and end users. Marbon Chemical Div., Borg-Warner. (A-19)

POLYPROPYLENE MOLDING AND EXTRUSION. 8-page brochure presents problems arising in the injection molding and extrusion of "Moplen" polypropylene, and the solutions to these problems. Includes discussion of capacity, pressures, molds, etc., comparison with high-impact styrene, low-density polyethylene. Chemore Corp. (A-20)

INJECTION MOLDING ACETATE, BUTYRATE. 51-page technical manual discusses the design, injection molding, and finishing of this company's "Tenite" acetate and butyrate. Eastman Chemical Products, Inc. (A-21)

GLASS-FILLED NYLON. Technical data sheet gives physical properties of three different grades of glass-reinforced nylon injection molding compounds. Fiberfil, Inc. (A-22)

GLASS-FILLED NYLON MOLDING COMPOUNDS. Technical sheet gives test data on mechanical, thermal, and electrical properties of three different types of this company's glass-filled nylon molding compounds. Fiberfil, Inc. (A-23)

VINYL RESINS. 4-page illustrated brochure describes advantages of this company's vinyl resins in the manufacture of toys, skins for bouncing horses, doll carriages and tops, foam plastic items, etc. Naugatuck Chemical Div., United States Rubber Co. (A-24)

METALLIC CASTING RESIN. 4-page bulletin describes liquid plastic for such casting or surface coat applications as the making of tooling, patterns, foundry covers. Lists physical properties and characteristics, and gives instructions for use. U. S. Gypsum Co. (A-25)

PLASTISOL RESIN. Illustrated 8-page brochure discusses the viscosity and air-release characteristics of a plastisol resin for slush and rotational molding, open and closed cell vinyl foam. Includes test recipes, molding recommendations, applications. Naugatuck Chem. Div., U. S. Rubber Co. (A-26)

LIQUID URETHANE PREPOLYMER. Series of technical bulletins describe a liquid urethane casting resin for use in compounding elastomeric, semi-rigid and rigid plastics, including products requiring good electrical properties. Bulletins also give coloring and release agents for use with this resin. Thiokol Chemical Corp. (A-27)

LIQUID POLYMER-EPOXY COMPOUNDS. 12-page brochure describes characteristics of a line of liquid polymer-epoxy resin combinations for potting, sealing, plastic tooling, and cold casting. Lists properties, fillers, mixing instructions, etc. Thiokol Chemical Corp. (A-28)

TOOLING RESIN. Bulletin describes an epoxy tooling "kit" that includes resin, hardener and glass cloth. Explains tool making procedure. Gives prices. United States Gypsum Co. (A-29)

PROCESSING POLYETHYLENE. Companion illustrated brochures, one 96 pages and the other 12, serve as processing guides to extruders, injection molders, bottle blowers and other converters of polyethylene. The larger publication describes processing technology while the smaller contains the latest information on polyethylene resins available from this company. U.S. Industrial Chemicals Co. (A-30)

MELAMINE. 32-page illustrated brochure discusses physical and chemical properties, and applications of melamine in plastic molding compounds, laminating resins, bonding and coating resins, paper resins, etc. Process Chemicals Dept., American Cyanamid Co. (A-31)

VINYL RESINS & COMPOUNDS. Illustrated 4-page brochure describes this company's new copolymers, paste resins, U.L. approved resins and cold blend resins. Lists specific viscosities, applications and advantages. Diamond Alkali Co. (A-32)

PVC RESINS. 52-page booklet discusses properties, handling, and applications of the "Vygen" family of polyvinyl chloride resins. Describes roles of plasticizers, stabilizers, colorants, fillers, and lubricants. Methods of processing, testing are also discussed. General Tire & Rubber Co. (A-33)

ACRYLONITRILE. 76-page bulletin discusses the polymerization and copolymerization of acrylonitrile, a versatile, reactive vinyl monomer. The bulletin includes monomer reactivity ratios and their utilization and designing experimental procedures. Petrochemicals Dept., American Cyanamid Co. (A-34)

VACUUM METALIZING COATINGS. 16-page brochure describes procedures for applying vacuum metalizing coatings to thermosetting plastics by hand or automatic spray, hot spray, electrostatic spray, and flow and dip coating. Bee Chemical Co. (A-35)

PVC RESINS, COMPOUNDS. Series of technical data sheets list the properties, applications and processing procedures for this company's lines of PVC resins and compounds. Plastics Div., Diamond Alkali Co. (A-36)

POLYETHYLENE PROCESSING. File folder contains booklet with information on the processing of polyethylene; also booklet with data on the heat-seal characteristics of polyethylene films. U.S. Industrial Chemicals Co. (A-37)

BULK POLYSTYRENE DELIVERY. Illustrated 4-page folder discusses advantages of bulk handling and delivery of general-purpose and high-impact pellet and crystalline polystyrene. Includes map of distribution zones. Cosden Petroleum Corp. (A-38)

FABRICATING EXPANDED POLYSTYRENE. 34-page handbook gives detailed instructions on sawing, planing, shaping, hot wire cutting, heat forming and grinding of expanded polystyrene. Also discusses selection and use of proper adhesives and coatings. Dow Chemical Company. (A-39)

PVC COPOLYMER RESINS. Technical data sheets describe a group of copolymer resins having a range of solution properties that enable the compounder to produce a solution with good coating properties and also the necessary physical characteristics of the dried coating. Properties listed. The Borden Chemical Co. (A-40)

VINYL SOLUTION RESINS. 16-page booklet discusses preparation, properties and compounding of Geon solution resins for paper coatings, food packaging, strippable coatings, printing inks, etc. B. F. Goodrich Chemical Co. (A-41)

GUIDE TO SILICONES. 12-page reference guide to this company's silicone products includes performance, property and application data on silicone laminating resins, adhesives, foamed structures, insulating materials, release agents, and molding compounds. Dow Corning Corp. (A-42)

LINEAR POLYOLEFIN RESIN. Series of technical bulletins discuss the properties, thermoforming, molding, extrusion, coloring and applications of "Fortiflex A", a high-density thermoplastic resin characterized by a linear structure. Plastics Div., Celanese Corp. of America. (A-43)

VINYL RESINS FOR RIGID APPLICATIONS. 8-page illustrated brochure gives the physical properties of two grades of vinyl resins along with Banbury and mill mixing, and extrusion processing conditions. B. F. Goodrich Chem. Co. (A-44)

INDUSTRIAL ADHESIVES. Data chart, covering this company's line of industrial adhesives, aids selection of the right adhesive for desired purpose, including bonding of difficult dissimilar materials, etc. Sama Paint & Lacquer Div., Flexcraft Industries. (A-45)

MELAMINE-FORMALDEHYDE MOLDING COMPOUNDS. Illustrated technical data file describes handling and molding of this company's "Cymel" molding compounds. Compounds are used in decorative applications for homes, offices, restaurants, etc.; also in industrial and military fields. Plastics and Resins Div., American Cyanamid Co. (A-46)

TOOLING PLASTICS. Illustrated 4-page bulletin describes advantages of this company's epoxy tooling resins for plastics tool manufacture in the aircraft, automotive, metal trades, etc., industries. Furane Plastics, Inc. (A-47)

ADHESIVES AND TAPES. 4-page illustrated brochure describes this company's lines of adhesives, available in liquid and paste forms for bonding of plastic, wood, clay, etc., parts. Furane Plastics, Inc. (A-48)

POLYESTER RESIN FACT FILE. Folder describes company's line of polyester resins, giving physical and chemical characteristics, processing methods, applications. American Alkyd Industries. (A-49)

COATING RESINS. Folder gives general line of information on "Teflon" and "Kel-F," specialized protective coatings for metal surfaces, and of a "Teflon"-impregnated and coated woven glass fabric. General Plastics Corporation. (A-50)

COLORED POLYESTER COMPOUNDS. 5-page illustrated bulletin describes available multi-colored thermosetting polyester molding compounds. Discusses molding procedures, curing time, fabricating, shelf life, etc. Durez Plastics Div., Hooker Chemical Corp. (A-51)

STYRENE FOR LIGHTING FIXTURES. Technical bulletin gives performance data and testing techniques for a styrene developed to provide improved resistance to yellowing for molded and extruded fluorescent lighting fixture components. Plastics Div., Monsanto Chemical Co. (A-52)

FLEXIBLE CASTING RESIN. Technical bulletin describes properties of an epoxy flexible casting resin which sets at room temperature. For potting and encapsulating of electronic components, production of molds, and as facings for drop hammer dies. Marblette Corp. (A-53)

PHENOLICS MOLDING COMPOUNDS. 14-page illustrated brochure discusses the manufacture, molding, physical properties of this company's phenolic molding compounds; also the design and finishing of end products. Durez Plastic Div., Hooker Chemical Co. (A-54)

CHEMICAL-RESISTANT RESINS. 4-page brochure describes a chemical- and corrosion-resistant resin, with flexural strength equal to that of polyesters and epoxies at room temperature. Resin maintains much of this strength at temperatures up to 100° C, making it suitable for many sterilization processes. Finishes Div., Interchemical Corp. (A-55)

FOAMED POLYSTYRENE. Illustrated 38-page booklet describes properties, characteristics, molding and fabricating methods, and product applications for expandable polystyrene. Koppers Co., Inc. (A-56)

URETHANE FOAM PRODUCTION SYSTEMS. Illustrated 8-page brochure describes how this company guides the selection of equipment, the installation, and the pilot operation of entire production systems for plants desiring to manufacture urethane foam. Jennings Engineering Co. (A-57)

FOAMED PLASTICS. 16-page booklet gives basic physical and chemical data on polyester, polyether, and urethane foamed plastics. Nopco Chemical Company. (A-58)

POLYESTER RESINS. Series of technical data sheets give properties of this company's general and special purpose casting, molding and laminating polyester resins. Pittsburgh Plate Glass Co. (A-59)

ADHESIVES FOR FILMS. 18-page handbook discusses types, characteristics, applications and methods of handling commercially available adhesives suitable for use on transparent film. Includes bulletin board pin-up film-selector chart. National Adhesives Div., National Starch Products, Inc. (A-60)

HOW TO MOLD RIGID POLYETHYLENE. Illustrated 8-page article gives detailed instructions on injection molding rigid Marlex 50 polyethylene. Covers feeding methods, mold and cylinder temperatures, injection pressures and speeds, and special mold design factors. Phillips Chemical Company. (A-61)

POLYESTER MOLDING MATERIAL. Ad reprint describes properties of a line of color polyester materials for compression or transfer molding. Discusses strength, fire-resistance, shrinkage, color opacity, and light-fastness. Durez Plastics Div., Hooker Chemical Corp. (A-62)

EPOXY AND POLYESTER PASTES. Separate booklets display color chips, discuss features and list prices for epoxy and polyester resin color pastes. Plastic Color Co. (A-63)

EPOXY RESINS. Technical bulletin describes clear and aluminum-filled epoxy resins for casting, laminating and adhesive uses where high heat resistance is required. Marblette Corp. (A-64)

POLYPROPYLENE. 10-page illustrated brochure discusses product and mold design, molding, processing, and fabrication of this company's lines of polypropylene. Uses include film, containers, pipe, business machines, etc. Cellulose Products Dept., Hercules Powder Co. (A-65)

TECHNICAL REPORT ON POLYETHYLENE. Illustrated 20-page technical booklet contains reports on the properties and structure of Marlex low pressure polyethylene for use in injection molding, extrusion, vacuum forming and welding. Phillips Petroleum Co. (A-66)

FOAM PRODUCING RESINS. Technical bulletins describe a resin that will produce a flexible polyurethane foam for slab stock, and seating and cushioning applications; also a resin for producing "Freon" blown film with good sound and heat insulation properties. Pelron Corp. (A-67)

PIGMENT DISPERSIONS. Brochure and accompanying color chip chart give mixing, pre-mixing and price information on this company's color paste dispersions for polyesters, epoxies, acrylics, etc. Pigment Dispersions, Inc. (A-68)

NEW THERMOPLASTIC POLYMER. 6-page technical bulletin describes a new, high molecular weight, linear and crystalline chlorinated polyether said to be highly resistant to thermal degradation at molding and extrusion temperatures. Cellulose Products Dept., Hercules Powder Co. (A-69)

EPOXY COATING COMPOUND. Technical bulletins list properties of a 100% epoxy dip coating compound for heat-sensitive electronic components and applications where low temperature curing is required. Includes specifications, application methods data, price list. Isochem Resins Corp. (A-70)

POLYPROPYLENE FACT BOOK. Illustrated 10-page booklet describes properties and applications of lightweight "Profax" polypropylenes for extrusion, coating, vacuum forming, compression and transfer molding, etc. Includes processing, design, and other data. Hercules Powder Co., Inc. (A-71)

BUTADIENE. 44-page illustrated brochure discusses the potentialities, physical and chemical properties, derivatives, specifications, analytical procedures and physiological properties of butadiene. Petro-Tex Chemical Corp. (A-72)

RESINS FOR FOREIGN DISTRIBUTION. Literature prepared for foreign subscribers lists types of thermosetting, thermoplastic and cellulosic resins in company's line. Also discusses colorants for plastics. Interplastics Corporation. (A-73)

TEFLON COATINGS. 8-page illustrated brochure describes advantages of Teflon coated metal surfaces, including resistance to acids, rust and corrosion; self-lubrication, quick release, etc. Industrial Plastic Coating Corp. (A-74)

POLYETHYLENE. Series of illustrated brochures describes this company's grades of polyethylene for use in the manufacture of plastic films, textiles, food packaging, food cartons, polishes, color concentrates, etc. Semet-Solvay Petrochemical Div., Allied Chemical Corp. (A-75)

DESIGNING NYLON PRODUCTS. 28-page manual discusses engineering design principles involved in developing product applications for nylon resins. Gives data on application of nylon's physical and chemical properties to design calculations. E. I. du Pont de Nemours & Co. (A-76)

POLYESTER RESINS. Technical guide describes and gives applications for this company's line of Laminac polyester resins. Data includes typical characteristics, general descriptions, curing characteristics, processing techniques, etc. Plastics & Resins Div., American Cyanamid Co. (A-77)

RESINS. 20-page illustrated brochure describes this company's fluorocarbon, nylon, polyethylene and acrylic resins. Discusses properties, characteristics and applications. E. I. du Pont de Nemours & Co., Inc. (A-78)

DIALLYL PHTHALATE MOLDING COMPOUND. Bulletin gives physical properties of five grades of diallyl phthalate molding compound. Lists properties of pieces molded from this high-dielectric material with emphasis on electrical applications. Acme Resin Corp. (A-79)

RESIN BOOKLET. 18-page illustrated booklet describes applications and properties of company's tetrafluoroethylene, nylon, polyethylene, and acrylic resins. E. I. du Pont de Nemours & Company, Inc. (A-80)

MOLDING COMPOUNDS AND RESINS. Illustrated 16-page booklet presents properties and applications of lines of unfilled, and cellulose, wood, asbestos, and glass-filled thermosetting compounds; a methylstyrene compound; and polyester, laminating, and adhesive resins. American Cyanamid Co. (A-81)

PLASTISOLS. Series of data sheets discuss the application of this company's plastisols as insulation, for proofing fabrics, for decorative and protective coatings; and for dipping wire goods, tool handles, marine equipment, etc. Stanley Chemical Co. (A-82)

URETHANE FOAMING RESIN. 12-page illustrated brochure and series of technical bulletins give catalysts, mold release agents and molding techniques for a urethane foaming resin. Applications include wall insulation, sandwich prefabrication, unit insulation in refrigeration equipment. Thiokol Chemical Corp. (A-83)

MEDIUM IMPACT POLYSTYRENE. Technical data sheets describe this company's medium impact polystyrene, developed for the indoor fluorescent lighting and sign industry. Material reportedly solves problem of discoloration due to the ultra-violet of fluorescent light bulbs. Sheffield Plastics, Inc. (A-84)

VINYL POLYMERS & COPOLYMERS. Reference booklet gives physical properties, compounding and processing characteristics, and applications of this company's vinyl polymers and copolymers. Rubber Corp. of America. (A-85)

POLYETHYLENE SPECIFICATIONS. 16-page technical booklet contains detailed specifications data on the general, mechanical, and electrical properties of the "Tenite" line of polyethylene resins. Eastman Chemical Products, Inc. (A-86)

ADHESIVES. Technical data sheet describes lines of thermoplastic resin adhesives with good adhesion to metal, glass, plastics, paper, fabrics and synthetic rubbers. Adhesives resist alkalies, acids, water, grease, etc. Research Sales, Inc. (A-87)

HIGH DENSITY POLYETHYLENE RESIN. Illustrated technical bulletin describes a high density polyethylene resin. Includes comparison of properties with conventional polyethylene. Spencer Chemical Co. (A-88)

NEWS FOR RESIN USERS. 28-page bulletin contains articles on a new post-stabilizer for natural and synthetic resins, a new acrylic coating resin with improved hardness and adhesion, the use of ion exchange in gelatin processing, etc. Resinous Prod. Div., Rohm & Haas Co. (A-89)

FOAMED PLASTIC. 28-page illustrated brochure describes structural, electronic and thermal insulation uses of "Nopco Lockfoam", a family of gas-expanded foamed plastics. Gives handling techniques, physical properties. Nopco Chemical Co. (A-90)

UREA. 4-page brochure gives physical properties of this company's grades of urea; lists uses in the manufacture of resinous materials, chemicals, etc. Grace Chemical Co. (A-91)

EPOXY COMPOUNDS. Series of technical bulletins describe a series of epoxy molding powders for the manufacture of coil and resistor bobbins, relay assemblies, plastic models of forge dies, plastic shaper forms for chair bottoms, etc. Houghton Laboratories, Inc. (A-92)

GLASS-FILLED STYRENE. Bulletin gives physical properties of three different grades of glass-reinforced styrene injection molding compounds. Fiberfil, Inc. (A-93)

EMULSIFIABLE POLYETHYLENE. 24-page technical bulletin describes wax-like polymer which improves wax emulsion coatings. Gives typical properties and discusses end uses and compatibilities with other materials. Semet-Solvay Petrochemical Division, Allied Chemical Corp. (A-94)

POLYPROPYLENE. 14-page illustrated booklet describes the features and properties of, and processing procedures for, applications of this company's "Moplen" polypropylene for pipe, foil and film, electrical, home, automotive and sanitary products. Montecatini. (A-95)

MOLDING MATERIALS IN COLOR. 6-page data file folder contains price schedule for lines of this company's synthetic resins now available in standard colors. Materials are for molding, extruding, calendering, and vacuum-forming. Marbon Chemical, Div. of Borg-Warner. (A-96)

REINFORCING RESIN. 4-page technical bulletin presents properties and advantages of the use of a granular, styrene-butadiene copolymer in natural and synthetic rubber formulation. Includes tables, graphs. Chemical Div., The Goodyear Tire & Rubber Co. (A-97)

ACRYLIC MOLDING POWDER. Illustrated 8-page booklet describes properties of grades of a modified acrylic high-impact powder for injection molding and extrusion of sheets, rods, and tubes. Includes technical data, fabricating techniques, applications. Rohm & Haas Co. (A-98)

RIGID POLYURETHANE FOAM SYSTEM. Technical bulletin describes a rigid polyurethane foam system, used in the manufacture of plastics foam products and in-place foaming operations. Gives features, uses, product characteristics, applications, etc. Reichhold Chemicals, Inc. (A-99)

ANTI-CORROSION COATINGS. 4-page illustrated brochure describes chemical corrosion-resistant, abrasion-proof PVC coating for machine parts, ducts, materials handling equipment, etc. Accompanying catalog sheets describe a similar PVC plastisol for spray applications; corrosion-proof sheets of plasticized PVC, etc. Quelcor, Inc. (A-100)

NYLON MOLDING COMPOUND. Technical bulletin describes a glass-reinforced nylon compound for injection molding. Its features include dimensional stability, resistance to impact. Bulletin discusses molding procedures, gives properties. Belding Corticelli Industries, Inc. (A-101)

VINYL RESINS & COMPOUNDS. Illustrated 4-page brochure describes this company's new copolymers, paste resins, U.L.-approved resins and cold blend resins. Lists specific viscosities, applications and advantages. Diamond Alkali Co. (A-102)

TOOLING RESIN. 8-page technical bulletin describes properties and outlines techniques for manufacturing plastic tools or patterns from a glue liquid epoxy resin that cures at room temperatures. United States Gypsum Company. (A-103)

VINYL SOLUTION RESINS. 16-page booklet discusses preparation, properties and compounding of Geon solution resins for paper coatings, food packaging, strippable coatings, printed inks, etc. B. F. Goodrich Chemical Co. (A-104)

NYLON RESINS. Technical sheet file folder describes the properties of, and application methods for, this company's line of nylon resins. Uses include protective coatings and bondings; also injection molded, extruded and compression molded products. Belding-Corticelli Ind. (A-105)

POLYURETHANE FOAM. Technical bulletin describes characteristics, properties, formulations, uses of a polyester and a polyether-based molded formulations. Reynolds Chemical Products Company. (A-106)

TETROFLUOROETHYLENE RESINS. 4-page illustrated bulletin compares properties and performance characteristics of Fluorosint TFE, a fluorocarbon-based resin with improved chemical and thermal properties with those of Teflon. The Polymer Corporation of Penna. (A-107)

PVC RESINS. Comprehensive 56-page manual gives details on company's line of PVC resins, accompanied by extensive data on plasticizing, stabilizing, coloring, and compounding. Includes much processing information and detailed explanation of test methods. General Tire and Rubber Co. (A-108)

VINYL RESINS. File folder of technical data sheets describes physical properties, recommended uses and applications for line of vinylfluoride and vinylacetate resins in a wide range of molecular weight. J. P. Frank Chemical Co. (A-109)

ADHESIVES, COATINGS, PRIMERS FOR VINYL CONVERTING. Data sheet file discusses lamination and converting of vinyl film. Describes end uses, markets, etc. Includes adhesives selection chart. National Starch Products, Inc. (A-110)

MONOMERS. 9-page technical bulletin gives data on dimetal Itaconate and dicalacized *n*-butyl Itaconate: two acid esters with interesting properties as intermediates and monomers in preparing plastics materials. Data sheets give properties, suggested uses, and information on polymerization procedures. Chas. Pfizer & Co. (A-111)

PLASTISOLS. Catalog and instruction manual gives characteristics and properties of a line of specialized plastisol formulations for hot and cold dipping, spraying, foaming and roll-coating. Includes data on pre-treatment of surfaces, baking cycles, required equipment, and suggested uses. Bradley & Vrooman Company. (A-112)

POLYESTER FINISHES. Illustrated brochure describes properties, uses and advantages of a specialized polyester resin, "Glid-Tile", available in glossy finishes and many colors, with special application in the coating of such building materials as concrete, cinder blocks, wallboard, wood and metal to provide a tile-like surface. The Glidden Company. (A-113)

Chemicals for Plastics

INDUSTRIAL CHEMICALS. 8-page catalog lists over 300 heavy and fine chemicals distributed by this company for a wide range of industrial applications. Includes lists of distribution points. McKesson & Robbins, Inc. (A-114)

VINYL STABILIZER. Bulletin describes general characteristics and properties of liquid heat and light stabilizer for clear vinyl plastics. National Lead Co. (A-115)

PLASTIC MATERIALS. 4-page folder describes this company's tinsels, metallics, phosphorescents and satin pearl effects; also its available cellulose acetate, polystyrene and polyethylene compounds. Plastics Materials, Inc. (A-116)

CHEMICALS FOR PLASTICS. 8-page catalog lists this distributor's chemicals and the nationwide system of warehouses from which they are available. McKesson & Robbins, Inc. (A-117)

PLASTICIZERS. 4-page technical bulletin describes a series of citric acid esters compatible with most generally useful polymers. Bulletin tells how these plasticizers can be used for specific requirements, particularly where nontoxicity is a prime factor. Chemical Sales Div., Chas. Pfizer & Co., Inc. (A-118)

ORGANIC PEROXIDES. Technical bulletins list specifications, properties, analyses, uses, storage and handling information, etc., for the Cadet Chemical Corporation's organic peroxides. Chem. Dept., McKesson & Robbins. (A-119)

CHEMICALS FOR PLASTICS. 12-page brochure describes this company's lines of plasticizers, activated carbons, protective coatings, and coal chemicals. Presents uses. Industrial Chemicals Div., Pittsburgh Coke & Chemical Co. (A-120)

PLASTISOL VISCOSITY DEPRESSANT. Technical data sheet describes a plastisol viscosity depressant said to improve heat stability, air release, and aid in the dispersion of pigments and fillers. Plastics and Chemicals Corp. (A-121)

PEROXIDIC CATALYST. Technical bulletin discusses the application of cumene hydroperoxide for curing polyester resins. The catalyst's advantages include ease of handling and versatile applicability. Naval Stores Dept., Hercules Powder Co. (A-122)

PETROCHEMICALS. 4-page catalog describes specifications and industrial applications of this company's lines of alcohols, olefins, diolefins, ketones, acetates, and ethers. Enjay Co., Inc. (A-123)

BLUE PIGMENT. 4-page technical bulletin describes a green shade, non-flocculating type phthalocyanine blue of exceptionally jet mass tone and bright green undertone. Pigment Color & Chemical Div., The Sherwin-Williams Co. (A-124)

FLUORESCENT, PHOSPHORESCENT PIGMENTS. 4-page folder describes properties and uses of fluorescent and phosphorescent pigments in plastics, printing, paper, textiles, paint, and rubber. United States Radium Corp. (A-125)

ORGANIC PEROXIDES. 8-page bulletin lists available organic peroxides for use as catalysts with vinyl, polyester, silicone and epoxy resins. Lucidol Div., Wallace & Tiernan, Inc. (A-126)

SECONDARY PLASTICIZER. 10-page technical bulletin describes an odorless, water-white synthesized secondary plasticizer for vinyl resins. Contains test data and plastisol viscosity study. Continental Oil Co. (A-127)

ORGANIC PEROXIDES. Technical bulletin catalog describes properties of a line of organic peroxides for polymerization of monomers and silicones, catalyzing, bleaching, etc. Includes uses, specifications, handling, storage, and shipping information. Cadet Chemical Corp. (A-128)

VINYL INKS. 5-page bulletin describes properties of a line of gravure inks for the multicolor printing of vinyl film, sheeting and coated fabrics. Claremont Pigment Dispersion Corp. (A-129)

DYESTUFFS FOR PLASTICS. Brochure pictures and describes uses of this company's lines of lacquers, dyes, adhesives, and cleaners, for acrylics, butyrate, styrene, vinyls, etc. Schwartz Chemical Co., Inc. (A-130)

ISOBUTYLENE. Chart outlines 213 present and potential uses of isobutylene, in copolymers, coatings, liners, insulating materials, adhesives, etc. Patent bibliography attached. Petro-Tex Chemical Corp. (A-131)

DRY COLORANTS FOR POLYSTYRENE, POLYETHYLENE. Brochure describes company's pre-lubricated dry colorants for polystyrene, high-impact styrene and polyethylene. Colorants can be used without wetting agents. Price list included. Riverdale Color Co., Inc. (A-132)

REACTIVE FLEXIBILIZER. 8-page technical brochure describes new, low-viscosity, reactive flexibilizer for epoxy resins, also in adhesive, body solder, casting, and laminating other applications. Plastics Div., Ciba Co., Inc. (A-133)

POLYMERIC PLASTICIZER. 8-page technical bulletin presents features and properties of a polymeric plasticizer for use with plastisols and vinyl resins. Includes tables of performance, resin compatibility, etc. Eastman Chemical Products, Inc. (A-134)

SILICA IN PLASTICS. 7-page bulletin describes colloidal silica as a thixotropic agent in polyesters and epoxy resins, in plastisols and organisols, and as a gelling agent in plastigels. Minerals & Chemicals Div., Godfrey L. Cabot, Inc. (A-135)

PLASTICIZER FOR VINYL RESINS. 12-page technical bulletin gives physical properties, data on line of plasticizer and plastisol extrusion applications. Continental Oil Co. (A-136)

COLORS AND PIGMENTS. Handbook lists properties, applications and prices for lines of colors and pigments used in the manufacture of paints, enamels, plastics, etc. C. K. Williams & Co., Inc. (A-137)

ALLOYS FOR MOLD-MAKING. Technical file folder describes a line of bismuth alloys used in making molds for plastic patterns, testing plastics, forming sheet or tubular plastics by vacuum air pressure, etc. Cerro De Pasco Sales Corp. (A-138)

COLORANTS FOR THERMOPLASTICS. Catalog discusses advantages of in-plant blending. Gives specifications and prices on its lines of polystyrene, hi-impact styrene, polyethylene and metallic colorants. Plastic Molders Supply Co., Inc. (A-139)

STABILIZERS FOR VINYLS. File folder contains data sheet on line of heat and light stabilizers for vinyl resins. Includes data on properties and applications. Nuodex Products Co. (A-140)

STABILIZER. Data on the specifications, physical properties, and the solubility of "RS-31," a vinyl plasticizer which imparts excellent heat stability, clarity, heat sealing, and printing characteristics. Metal & Thermit Corp. (A-141)

STABILIZERS. Technical bulletin outlines general characteristics, typical properties and recommended uses in vinyl electrical insulation of a lead-chlorophthalosilicate stabilizer. National Lead Co. (A-142)

EPOXY CURING AGENTS. Technical bulletin describes two new co-reactants that cure epoxy resins at room temperature. The results are new polymers useful for coatings, casting, potting, adhesives and laminates. Chemical Div., General Mills. (A-143)

PASTE COLORS FOR POLYESTERS, EPOXIES. Booklets containing color samples give properties, use procedures and prices on this company's lines of color pastes for epoxy and polyester resins. Plastics Color Co. (A-144)

PLASTICIZERS. 17-page technical bulletin describes the properties, specifications and performance features of this company's line of plasticizers for vinyls. B. F. Goodrich Chemical Co., Div. The B. F. Goodrich Co. (A-145)

OXO ALCOHOLS. 23-page technical bulletin discusses properties and behavior characteristics of octyl and dectyl alcohols, and their role in the production of ester plasticizers. Enjay Company, Inc. (A-146)

EPOXY COLOR PASTES. 4-page folder describes the properties and uses of epoxy color paste compounds in casting, sealing, molding, extruding, potting, coating, and other operations. Includes colors. The Clinton Company. (A-147)

EPOXY PLASTICIZERS FOR VINYL RESINS. 26-page technical booklet charts performance data, compatabilities, and properties of three epoxy plasticizers that also possess stabilizing functions in vinyl resins. Archer-Daniels-Midland Co. (A-148)

ALUMINUM SILICATE PIGMENTS. 4-page brochure gives the basic properties of this company's line of standard-grade aluminum silicate pigments for use in adhesives, plastics, printing inks, etc., as well as conditioning agents in other chemical products. Minerals & Chemicals Corp. of America. (A-149)

EPOXY CURING AGENTS. Technical data sheets describe the properties and applications of dicarboxylic acid anhydrides as curing agents for epoxy resins. Include formulations, curing schedules, handling information, etc. National Aniline Div., Allied Chemical Corp. (A-150)

VINYL STEARATE PLASTICIZER. Technical data sheets discuss properties, applications of vinyl stearate and its copolymerization with other monomers. Include information on solvency, handling, polymerization, halogenation, etc. Air Reduction Chemical Co. (A-151)

COLORED INKS. Series of bulletins describe this company's quick-drying, nonsmudge, waterproof and indelible inks for marking plastics, cellophane, highly glazed surfaces, metallic labels, etc. Acromark Co. (A-152)

CHEMICALS FOR PLASTICS. 16-page catalog describes and gives uses for this company's line of industrial chemicals. Includes tar acids and oils, plasticizers, "CUMAR" Resins, maleic anhydride, fumaric acid, etc. Plastic and Coal Chem. Div., Allied Chemical Corp. (A-153)

PHTHALIC ANHYDRIDE. 8-page technical bulletin describes a phthalic anhydride for use in the manufacture of alkyd resins, plasticizers, and dye intermediates. Gives specifications, properties and handling information for both flake and liquid forms. Reichhold Chemicals, Inc. (A-154)

COLORANTS FOR PLASTICS. 4-page technical bulletin describes the general properties of each of the grades of Cadmium Selenide Red, Mercury-Cadmium Red, and Cadmium Yellows produced by this company for thermoplastic and thermosetting resins. Includes color chips, physical constants, applications. Kentucky Color and Chem. Co., Inc. (A-155)

PLASTICIZER STUDY. 11-page compounding study evaluates properties of primary and secondary plasticizers used with this company's "Pliovic AO" plastisols. Chem. Div., The Goodyear Tire & Rubber Company. (A-156)

VINYL STABILIZER. Technical bulletin gives heat stability characteristics, electrical and other properties of a stabilizer developed for primary vinyl electrical insulation. National Lead Co. (A-157)

SLIP AND ANTI-STATIC AGENT. Illustrated 4-page brochure describes an agent that prevents static, tackiness and blocking during the extrusion and molding of polyethylene. Agent has a light color, low fatty acid and low soap content, low toxicity, etc. Fine Organics, Inc. (A-158)

EPOXY PLASTICIZERS. 4-page technical bulletin describes three epoxy plasticizers, designed to give vinyl compounders high protection against heat and light deterioration. Emery Industries, Inc. (A-159)

PLASTISOL STABILIZERS. Two 2-page leaflets describe recommended applications, usages and physical properties of two new liquid stabilizers for plastisols: barium-zinc and cadmium-barium-zinc. Ferro Chemical Corp. (A-160)

POLYMERIC PLASTICIZERS. 12-page technical bulletin describes a polymeric plasticizer for use in the manufacture of PVC electrical wire coatings and tapes, film and sheeting and adhesive-backed film and sheeting. Organic Chemicals Div., Monsanto Chemical Co. (A-161)

STABILIZERS. 41-page handbook discusses solutions to problems encountered in stabilizing polyvinyl chloride resins. Presents recommendations for rigid, flexible vinyls, plastisols and organisols, expanded vinyls, and homogeneous and asbestos tile. Ferro Chemical Corp. (A-162)

POLYVINYL METHYL ETHER. 12-page technical booklet describes properties, compatibility with other resins and polymers, and viscosity of polyvinyl methyl ether suitable as a heat-sensitizing agent for latices; a tackifier or plasticizer for adhesives, cements, lacquers and coatings. General Aniline & Film Corp. (A-163)

VINYL STABILIZER. 4-page brochure describes a vinyl stabilizer said to minimize performance variations due to resin or plasticizer or filler; and to eliminate storage problem due to exposure of stabilizer or compound to oxidation or moisture. The Harshaw Chemical Co. (A-164)

PVC PLASTICIZERS. 6-page technical bulletin discusses the properties and performance of a line of primary phthalate plasticizers for polyvinyl chloride plastisols, extrusions, coatings and sheeting compounds. Monsanto Chemical. (A-165)

VINYL PLASTICIZERS. 28-page catalog describes a line of epoxy plasticizers for vinyl resins. Gives data on physical properties, compatibilities, heat stability, performance. Suggests recommended uses and compounding formulations. Archer-Daniels-Midland Co. (A-166)

FLAME-RETARDING PLASTICIZER. 12-page technical bulletin describes tricresyl phosphate, a monomeric plasticizer for imparting flame retardance to polyvinyl chloride, nitrocellulose, and other synthetic resins. Organic Chemicals Div., Monsanto Chemical Co. (A-167)

VINYL STABILIZERS. Illustrated folder describes properties and applications of vinyl stabilizers. Presents recommended formulations for plastisol foam and sponge, spread and dip coatings, slush and centrifugal molding compounds, etc. The Harshaw Chemical Co. (A-168)

PLASTICIZERS FOR CHLOROFLUOCARBONS. 5-page technical bulletin describes this company's special line of oils —low polymers of chlorotrifluoroethylene —for use as plasticizers in fabricating softer and more flexible shapes made of chlorofluorocarbon plastics. Halocarbon Products Corp. (A-169)

VINYL LUBRICANT. Folder describes specifications and properties of a beaded wax which acts as a lubricant during extrusion and is said to impart a "patent leather" finish. Lanair Co. (A-170)

STABILIZERS. Series of 12 technical service bulletins describe an equal number of special purpose stabilizers for vinyls. Properties of each are tabulated and recommended uses are indicated. Witco Chemical Company. (A-171)

POLYETHYLENE, VINYL COLORS. 4-page listing gives prices for vinyl and polyethylene color concentrates available in either fine or course granulation. Cooke Color & Chemical Co. (A-172)

MONTHLY BULLETIN ON CHEMICAL PRODUCTS. Technical data sheets and bulletins in loose-leaf page form are issued monthly as an up-to-date reference file on a line of resins, plasticizers, stabilizers and specialty chemicals. J. P. Frank Chemical Co., Inc. (A-173)

Film, Sheeting, Rods, Tubes

PLASTIC TUBING. Series of catalog sheets give specifications for, and features of, this company's stocks of heavy-walled, flexible and instrument Teflon tubing; also Teflon rods. Sheets also list applications. Pennsylvania Fluorocarbon Co., Inc. (A-174)

METALLIC DECORATIVE PLASTICS. Illustrated folders describe this company's metallized cellulose acetate, polystyrene, butyrate and Mylar for decorating appliances, furniture, auto interiors, radio and television sets, vending machines, etc. Coating Products, Inc. (A-175)

SHEETS, RODS, TUBES. Properties chart lists electrical, mechanical, thermal, chemical and physical properties of commonly used plastics fabricating materials, including nylon, acrylic and acetate. Commercial Plastics & Supply. (A-176)

POLYETHYLENE GUIDE. 32-page illustrated booklet discusses nature and basic resin characteristics of polyethylene; also environmental effects on this material. Also discusses polyethylene's applications in film, moldings, pipe, coatings, etc. Outlines history and services of company. Spencer Chemical Co. (A-177)

FORMING CELLULOSE ACETATE. 12-page bulletin discusses the thermal forming of products from cellulose acetate sheet and roll stock. Includes forming equipment and techniques, decorating, design principles, supply sources, properties table, etc. Celanese Corp. of America. (A-178)

REINFORCED EXTRUSIONS. 4-page folder lists typical electrical and electronic applications for polyester-glass and epoxy-glass rods, tubes, and shapes made by a continuous extrusion process. Gives specifications. Polygon Plastics Co. (A-179)

SHEETS, RODS, TUBES. 8-page illustrated catalog lists specifications for this company's nylon, polystyrene, Teflon, and chlorinated polyether rods, tubing, sheets, bars, strips and tapes, etc. The Polymer Corp. of Pa. (A-180)

EXPANDED POLYSTYRENE BOARD. Illustrated 4-page folder describes features of low-density expanded polystyrene, available in standard and self-extinguishing grades, block and board forms, differing densities. For thermal insulation, packaging, display, etc. Styrene Products, Ltd. (A-181)

DECORATIVE VINYL SHEETING. 16-page illustrated brochure discusses features and fabricating techniques of this company's semi-rigid vinyl sheeting, available in colors and various finishes for bonding to steel and other non-ferrous metals. Applications include desk and table tops, luggage, seats, kitchen cabinets, advertising displays, etc. Columbus Coated Fabrics Corp. (A-182)

FABRICATING EXTRUDED ACRYLIC SHEETS. 12-page bulletin describes handling, machining, forming, cementing and annealing of extruded acrylic sheets. Includes properties table and light transmittance charts. Cadillac Plastic & Chemical Co. (A-183)

POLYESTER FILM. Series of illustrated booklets describe "Mylar", a polyester film used in the manufacture of wire, signs and decals, transformers, metallic yarn, pure sensitive tapes, decorative laminates, etc. Film Department, du Pont. (A-184)

PVC PIPE. 4-page price list tabulates available sizes and pressure ratings of line of unplasticized polyvinyl chloride pipe stocks, with high chemical or impact resistance. Alpha Plastics, Inc. (A-185)

METALLIZED THERMOPLASTIC SHEETING. Color card shows available metallic colors on this company's plastic sheeting. Accompanying bulletins describe vacuum forming of acetate and butyrate sheeting. Gomar Mfg. Co., Inc. (A-186)

NON-STAINING VINYL SHEETING. 4-page illustrated brochure describes a white vinyl metal laminate said to be completely non-staining. Sheeting makes possible linen, leather, lustrous finish effects on appliances. Columbus Coated Fabrics Corp. (A-187)

SHEETS, RODS, TUBES. 64-page price catalog lists available plastic sheets, rods, tubes, films, and lay-flat tubings in cast, extruded, and laminated shapes. Includes sizes, weights, color ranges, grades, etc. Cadillac Plastic & Chemical Co. (A-188)

NYLON TUBES, TAPES, RODS. Illustrated catalog sheet presents features and specifications of lines of standard extruded nylon tubes, tapes, pipes, and rods. Danielson Mfg. Co. (A-189)

PLASTIC PIPE. Illustrated catalog describes this company's lines of corrosion-proof, root-proof, free-flowing pipe and fittings. Yardley Plastics Co. (A-190)

RIGID THERMOPLASTIC SHEETS. Illustrated 8-page booklet discusses applications of this company's lines of polyvinyl chloride, styrene, polyethylene, etc. Materials available in press-laminated, calendered, and extruded sheets. Plastics Div., Seiberling Rubber Co. (A-191)

SHEET, ROD, TUBE CATALOG. Extensive catalog gives dimensions, specifications, colors and prices of line of extruded, cast and molded sheet, rod, and tube stocks. Cadillac Plastic & Chemical Co. (A-192)

THERMOPLASTIC SHEET AND EXTRUDED SECTIONS. File folder contains price lists, illustrated data sheet and comparative properties chart for thermoplastic materials extruded and molded by this company. Southern Plastics Company. (A-193)

CAST ACRYLIC SHEETS. 4-page leaflet describes the properties of a new precision-cast acrylic sheet with close thickness tolerances and high optical clarity for windshields, signs, domes, cake box covers, etc. Cast Optics Corp. (A-194)

TEFLON, KEL-F PRODUCTS. 32-page illustrated brochure describes this company's extensive line of molded and fabricated Teflon and Kel-F sheet, rod, tube stocks and such other products as gaskets, tapes, packings, and adhesives. Raybestos-Manhattan, Inc. (A-195)

LAMINATED SHEETS, RODS AND TUBES. 24-page illustrated catalog describes characteristics, properties and applications of line of high-pressure laminated sheets, rods and tube stock. Gives machining and design data. Synthane Corp. (A-196)

STOCK PLASTIC SHEETS. 64-page catalog bulletin lists available sizes, weights, color ranges, textures, purchasing specifications, grades and prices of an extensive range of plastic sheets, rods, tubes, films, blocks, and flat tubings. Also covers cements, pigments and miscellaneous plastics and supplies. Cadillac Plastic & Chemical Co. (A-197)

POLYSTYRENE FOR MACHINING. Pamphlet describes high-impact rod available in diameters up to 2½ in., tubing in diameters up to 3 in., and sheet up to 2 in. in thickness, for the machining of small parts. Westlake Plastics Co. (A-198)

FLUOROCARBON PLASTICS STOCKS. 12-page catalog describes available Teflon and Kel-F beading, extruded and molded rod, sheet, molded sleeves, electrical spaghetti, tape, and tubing. Plastics Div., The Garlock Packing Co. (A-199)

RIGID VINYL FOR EXTRUSION. 12-page illustrated brochure presents design advantages, chemical immersion data and applications for two unplasticized compounds, consisting of high molecular weight polymers compounded with stabilizer, lubricant and pigment. B. F. Goodrich Chemical Co. (A-200)

PLASTIC SHEETING. 4-page leaflet outlines the types, formulations, and uses of this company's light, medium, and heavy gauge "Kodapak" thermoplastic cellulose ester sheeting. Eastman Kodak Co. (A-201)

DECORATIVE VINYL SHEETING. 15-page illustrated brochure discusses features and fabricating techniques of this company's semi-rigid vinyl sheeting, available in colors and various finishes for bonding to steel and non-ferrous metals. Applications include desk and table tops, luggage, seats, kitchen cabinets, advertising displays, etc. Columbus Coated Fabrics Corp. (A-202)

Fillers and Reinforcements

CLAY FILLER FOR REINFORCED PLASTICS. 20-page technical handbook contains comprehensive discussion of use of hydrite kaolinites as fillers for reinforced plastics. Includes chart and graph data of kaolinite-filled resins. Georgia Kaolin Co. (A-203)

GLASS FIBER ROVING. Illustrated 8-page folder describes case history applications of Garan, Vitron and chrome roving for rod stock, molding compounds, mat, preforming, woven roving, etc. L.O.F. Glass Fibers Co. (A-204)

ASBESTOS FIBER. 4-page illustrated folder presents features of asbestos fiber as a bulking, reinforcing, hardening, fire-and-heat resistant filler in phenolics and other thermosetting plastics, and in thermoplastic molding compounds. Includes property chart. Johns-Manville. (A-205)

WOOD FLOUR FILLER. Illustrated brochure describes production and features of Eastern White Pine wood flour as a filler in the manufacture of vinyl flooring and other plastic products. Includes specifications. Wilner Wood Products Co. (A-206)

WOVEN ROVING FABRICS. Technical data sheets describe this company's styles of woven roving fabrics for laminating. Prices included. Bean Fiber Glass, Div. D. D. Bean & Sons Co. (A-207)

HYDROUS ALUMINA SILICATES. 8-page illustrated brochure describes chemical and physical properties of three of this company's hydrous alumina silicates as fillers in plastics. Summit Mining Corp. (A-208)

FIBROUS GLASS REINFORCEMENTS. Literature discusses qualities of reinforcing, surfacing and carrier, low density, and bonded mats for fibrous glass reinforcements. Includes diagrams of grain structures. Modiglas Fibers, Inc. (A-209)

GLASS FABRICS. 31-page handbook discusses properties, construction, processing, finishing, etc., of this company's grades of glass fabrics for electrical, boating, tooling, etc., applications. United Merchants Industrial Fabrics. (A-210)

HYDRITE KAOLINITES IN REINFORCED PLASTICS. 20-page brochure describes the advantages, minerology and properties of, and mixing molding techniques for, this company's line of hydrite kaolinites in reinforced plastics. Also gives cost comparisons. Georgia Kaolin Co. (A-211)

GLASS FABRICS. 4-page specification guide gives properties, weave and weight information, etc., on this company's lines of glass cloth. Flightex Fabrics, Inc. (A-212)

KAOLIN FILLERS IN POLYESTERS. Series of technical data sheets gives chemical and physical properties of ball clay, crystalex kaolin and Micronex, a naturally occurring kaolinate. Edgar Plastic Kaolin, Inc. (A-213)

Laminates and Reinforced Plastics

FABRICATING LAMINATED PLASTICS. 4-page illustrated folder outlines this North Carolina company's services for the fabrication of laminated plastic parts, particularly industrial Formica. Plastic products available include sheets, tubes, rods and molded items. Engineered Plastics, Inc. (A-214)

SANDWICH PANELS. Illustrated 6-page brochure describes the available types and patterns of this company's translucent sandwich panels of polyester resin and glass fibre. Applications include spandrel panels, sliding door panels, partitions, drop ceilings, etc. Naugatuck Chemical Div., U.S. Rubber. (A-215)

LAMINATED TUBE AND PIPE. Technical bulletin describes applications, properties and chemical resistance of fibrous glass-reinforced tube and pipe. Engineered Plastics, Inc. (A-216)

LATICES. 22-page illustrated brochure presents features and properties of lines of latices as used for the coating and impregnation of fabric, paper, leather, and non-woven constructions to impart superior abrasion resistance and tensile strength, good washing characteristics, etc. B. F. Goodrich Chemical Co. (A-217)

PRE-IMPREGNATED FIBREGLASS CLOTH. 8-page technical bulletin lists specifications for a pre-impregnated fibreglass cloth using a special high temperature phenolic resin. Cloth can be fabricated into flame barriers, antenna housings, fuel tanks, radomes, rocket nozzles, fins, etc. Eli Sandman Co. (A-218)

ABRASION-RESISTANT FABRIC. 6-page illustrated brochure describes a fabric impregnated with a solvent-activated plastic. This waterproof, non-corrosive material has been used for automobile body repair, shoes, artificial limbs, small-craft hulls, etc. Wasco Products, Inc., Div. of Wasco Chemical Co., Inc. (A-219)

PRE-IMPREGNATED FABRICS, PAPERS. File folder contains technical data sheets describing this company's lines of pre-impregnated fabrics and papers for laminating and molding. Lines include laminates for printed circuits, boats, aircraft components, etc. Polyplastex United, Inc. (A-220)

LAMINATED PLASTICS. Illustrated booklet describes this company's experience and facilities for fabricating laminated plastics and vulcanized fibre parts. Taylor Fibre Co. (A-221)

REINFORCED FIBER GLASS. 20-page illustrated brochure describes this company's design-to-production service for plastic reinforced fiber glass products. Industrial Products Div., The General Tire & Rubber Co. (A-222)

REINFORCED PLASTICS. Data sheets give chemical, electrical, and thermal properties of reinforced plastics materials used in the manufacture of rockets, missiles and aircraft. Raybestos-Manhattan, Inc. (A-223)

MOLDABLE INSULATING BASE. 10-page technical bulletin describes a phenolic impregnated, cellulose fiber sheet used as an insulating base in molded printed wiring board. Rogers Corp. (A-224)

PLASTIC IMPREGNATED MATERIALS. 20-page illustrated brochure describes features and uses of resin-impregnated papers for decorative laminates, phenolic-impregnated papers for industrial applications, phenolic-impregnated fabrics for high and low pressure molding, phenolic, polyester, epoxy and silicone-impregnated glass cloth, etc. Fabricon Products, A Div. of Eagle-Picher Co. (A-225)

REINFORCED PLASTIC. Technical bulletin describes "Scotchply," a moldable epoxy-glass laminate designed for production and supplied in roll or sheet form. Includes highly detailed properties charts and graphs. Minnesota Mining and Manufacturing Co. (A-226)

COPPER COVERED PHENOLITE. Illustrated 6-page folder discusses the manufacture, assembly, characteristics and uses of copper clad phenolite as a basic foundation in printed circuitry. Includes basic grade list and properties chart. National Vulcanized Fibre Co. (A-227)

REINFORCED TEFLON. Technical bulletins describe properties and applications of this company's reinforced Teflons as high temperature dielectric materials; also the use of reinforced Teflons in chemical processing, the aircraft and missile industries, etc. Rogers Corp. (A-228)

REINFORCED MOLDING COMPOUNDS. Brochure describes line of pre-mixed thermosetting fibre reinforced molding compounds containing polyester resins, fillers, pigments and fibres. Woodall Industries, Inc. (A-229)

REINFORCED PLASTICS. Brochure contains recommendations for hand layup of such structures as boats and radomes. Procedures covered include mold preparation, pigmenting, mold parting. Mol-Rez Corp. (A-230)

LAMINATES. Illustrated folder describes the features and manufacture of clad and unclad phenolic laminates for the electrical and electronics industries. Lists available grades together with their characteristics. New England Laminates Co., Inc. (A-231)

POST FORMING LAMINATES. 13-page handbook describes this company's thermoplastic methacrylate bonded glass cloth filled plastic materials. Discusses heating, forming, fabrication and tooling. Swedlow, Inc. (A-232)

PRE-IMPREGNATED MATERIALS. Kit contains descriptive literature on available phenolic, polyester, epoxy and silicone pre-impregnated glass fabrics, mats and papers. Samples included. Standard Insulation Co. (A-233)

POLYESTER PRE-IMPREGNATED GLASS CLOTH. File folder contains sample, technical data on flame-resistant polyester resin pre-impregnated glass cloth for use in laminates for electrical and electronic applications. Standard Insulation Co. (A-234)

Custom Services

PLASTICS TESTING SERVICE. Literature describes services and facilities of company that tests the performance and aging of plastics products under severe weathering and sunlight conditions. South Florida Test Service. (A-235)

PLASTIC MOLDINGS. 8-page brochure describes this company's services and facilities for making custom engineered cold and hot molded products, possessing desirable heat resistance, non-tracking, arc quenching and dimensional stability properties. Rostone Corp. (A-236)

PRECISION MOLDS. Bulletin outlines this midwest firm's engineering and tool room facilities for designing and building plastic molds and dies. Information includes full inventory of company's mold-making equipment. Damen Tool & Engineering Co. (A-237)

CUSTOM FABRICATION SERVICE. 4-page illustrated brochure describes this company's custom services for the precision fabrication of Plexiglas, acetate, vinylite, styrene, Teflon, phenolics, etc. Parts include discs, washers, terminal boards, etc. Comco Plastics, Inc., Div. of Commercial Plastics & Supply Co. (A-238)

REINFORCED PLASTICS PRODUCTS. Series of illustrated brochures describe this company's drafting, research, testing, mold making and molding facilities for the manufacture of molded fiberglass reinforced parts and sandwich structures. Winner Manufacturing Co., Inc. (A-239)

CHECK LIST FOR PURCHASING CUSTOM MOLDED PLASTICS. Technical report contains 14-question check list, pointing out ways manufacturers can make savings in the purchase of custom-molded components. Plastics Div., Monsanto Chemical Co. (A-240)

CHEMICAL TESTING SERVICES. 4-page illustrated brochure describes this company's services as an independent laboratory for chemical analysis and testing, research and development. Chemical Div., U. S. Testing Co., Inc. (A-241)

CUSTOM MOLDING. Illustrated 4-page brochure describes this company's services and facilities for custom molding and finishing parts from thermosetting plastics. Kurz-Kasch Co. (A-242)

CUSTOM MOLD FABRICATION. 4-page brochure describes economical process for custom casting of mold and die components in steel, iron or non-ferrous metals from low-cost brass, aluminum or zinc patterns. Information on process, advantages and applications are given. Manco Products, Inc. (A-243)

METALIZED PLASTICS. 4-page illustrated brochure describes techniques and applications of the barrel plating process for metalizing small plastics products such as toys, buttons, jewelry, hardware, etc. Planet Plating Co., Inc. (A-244)

PERFORATING SERVICE. 16-page booklet describes custom service for perforating, slitting, and blanking plastic materials. Describes available patterns. Perforating Industries, Inc. (A-245)

CUSTOM PLASTIC PRODUCTION. 30-page brochure discusses plastics materials, design concepts, fabricating processes, applications. Presents this company's available plastics production facilities, and development and manufacturing services. Goodyear Aircraft Corp. (A-246)

GERMAN-BUILT MOLDS. 4-page illustrated brochure describes this company's services for designing injection molds, and also its facilities for building the molds in Germany. Alfred A. Rosenthal. (A-247)

CUSTOM COMPRESSION MOLDING. Illustrated 4-page brochure describes this company's services and facilities for design, engineering, mold building, experimental work, long or short production runs, and insert work with thermosetting materials. Delta Plastics Co. (A-248)

PLASTIC FUSION BOND FINISHES. 4-page illustrated brochure describes advantages of cladding wire products, metal stampings, large castings, etc., with nylon, epoxy, vinyl, etc., finishes. Advantages include high surface gloss, chemical resistance, wide color range, etc. Engineered Plastics, Inc. (A-249)

URETHANE FOAM TAPE. Series of illustrated data sheets describe a urethane foam tape used for insulation, cushioning and noise reduction. Tape is pressure sensitive and adheres to smooth, clean surfaces after removal of foil backing. Sample included. United Mineral & Chemical Corp. (A-250)

CUSTOM PERFORATING. Illustrated 16-page brochure describes this firm's custom perforating, slitting and blanking services on roll and sheet plastics up to 72 in. wide. Included is an extensive series of full-size reproductions of available perforation patterns. Perforating Industries, Inc. (A-251)

CUSTOM MOLDINGS. Illustrated 4-page brochure describes this company's services and facilities for custom molding and finishing thermosetting plastic parts. Kurz-Kasch Co. (A-252)

ROLLED LEAF. Folder and accompanying samples provide data on a line of specialized rolled leaf stocks for use on plastic surfaces. Included are high gloss and flat textures in colors and imitation gold and silver. Admiral Coated Prods., Inc. (A-253)

ROLLER BEARING SERVICE. 4-page illustrated brochure outlines this company's services for assisting machinery builders in all aspects of bearing application engineering. The Timken Roller Bearing Co. (A-254)

PEARL ESSENCE FINISHES. 12-page booklet discusses the properties, application methods and features of this company's natural pearl essence and synthetic pearl pigment in the decoration of jewelry, pins, buttons, baby goods, toys, appliances, etc. Argenta Products. (A-255)

KNOBS. Companion illustrated catalogs list available thermosetting and thermoplastic knobs available in any desired colors. Waterbury Company, Inc. (A-256)

EXTRUSION FACILITIES. 8-page illustrated brochure describes this company's services for the design of special shapes, development of special compounds, building of complicated dies, etc. Includes sample and specifications for line of clear vinyl tubing. Vogt Mfg. Corp. (A-257)

ELECTROFORMED MOLD CAVITIES. Technical data sheet describes this company's services for the manufacture of nickel-surfaced mold cavities. Cavities so treated are immune to rust, oxidation and effects of molding lubricants. Camin Laboratories, Inc. (A-258)

Machinery, Equipment and Supplies

DECORATIVE MARKING MACHINES. Catalog carries descriptions and prices of lines of hand-operated bench models, air- and motor-driven bench and floor models, etc., for the marking of molded or fabricated thermoplastics and thermosets. The Acromark Co. (A-259)

LIFT TRUCKS. Brochure describes lift trucks capable of lifting and moving every type of load up to 2,000 lbs. Trucks have 180° steering arc, weigh about 2,000 lbs. John Morrell Mfg. Co. (A-260)

TEMPERATURE CONTROLS. 8-page catalog gives specifications and prices for this company's lines of recording, indicating and non-indicating controls; thermometers, bulb installation accessories and mercury bulb elements, etc. Instruments are used in industrial heating and refrigeration. The Partlow Corp. (A-261)

EXTRUDERS, BLOW MOLDING MACHINES. 24-page brochure describes line of German built extruders and special extrusion heads for specific production; also blow molding machines for the manufacture of bottles, dolls, toys, household articles, etc. Barclay Industries. (A-262)

FLOW PROPERTIES MEASURER. Bulletin discusses versatile, heavy-duty instrument for recording flow properties of plastics. Describes its use in the carbon brush and electrodes industries. C. W. Brabender Instruments, Inc. (A-263)

INJECTION MOLDING MACHINES. Literature illustrates and describes line of two, three, and four-ounce hydraulic injection machines with plasticizing capacities ranging from 50 to 90 lbs. per hour. Specifications included. Moslo Machinery Co. (A-264)

ANTISTATIC COMPOUND. Bulletin describes paste, cream, liquid and liquid concentrate forms of a coating compound for neutralizing positive and negative charges on the surface of plastic materials. Optics Manufacturing Corp. (A-265)

INJECTION PRESS. 2-page illustrated bulletin discusses a ¼-oz., up to 225 cycle/hr. air-operated thermoplastic injection press for experimental short runs, small precision parts, etc. Specifications included. Simplomatic Mfg. Co. (A-266)

STRIP COATING PRODUCTION LINE. 4-page bulletin #RW-500 describes a production line for strip coating coiled steel, tin-plate, aluminum and other metals. Schematic drawing of line, photos of machines, description of each step. Midland-Ross Corp. (A-267)

METERING-MIXING MACHINE. 4-page illustrated folder describes a machine for metering, mixing and dispensing epoxies, polyesters, polyurethanes, etc. Machines provide for single shot sizes up to 1 pt. and larger. Automatic Process Control. (A-268)

MARKING MACHINES. 6-page illustrated brochure describes line of hand- and air-operated precision machines for marking a variety of plastic parts including lipsticks, pen holders, name plates, control knobs, etc. Kingsley Stamping Machine Co. (A-269)

PLASTICS SQUARING SHEARS. 8-page booklet describes and pictures the construction features of lines of 14-20 gauge all-steel, foot-, air- and power-drive shears. Includes specifications, accessories. Famco Machine Co. (A-270)

MOLDING PLASTERS. 4-page brochure describes this company's lines of custom-made plasters for patterns, case and block molds, shell casts, etc. Bestwall Certain-Teed Sales Corp. (A-271)

STRIPPABLE PLASTIC COATING. 4-page illustrated brochure describes a spray-on, strippable plastic coating that protects smooth and highly polished surfaces from scratches, rust, acids, alkalies, and oils, during fabrication, handling and storage. Guard Coatings Corp. (A-272)

RAPID MOISTURE TESTER. 6-page illustrated brochure describes a semi-automatic machine that determines the moisture content of organic and inorganic materials in two steps instead of the conventional five-step methods. C. W. Brabender Instruments, Inc. (A-273)

INFRA-RED HEATING MODULES. Engineering data sheet describes heating, reflector and wiring duct modules, and angles, for installation in flexible, "build-it-yourself" ovens. Ovens can be used for baking, drying, preheating, curing, etc. Infra-Red Systems, Inc. (A-274)

ENGRAVED INKING ROLLS. Illustrated technical bulletin presents features and dimensions of engraved rolls for the metered application of inks, plastics, adhesives, and fluids. Paper Machinery & Research, Inc. (A-275)

ELECTRIC MOTORS. 16-page illustrated brochure describes this company's drip-proof, totally enclosed and explosion-proof electric motors over the full 125-horsepower range. Small AC Motor and Generator Department, General Electric Co. (A-276)

TWO-PART RESIN DISPENSER. Four-page illustrated brochure describes the design, operation and means of automating the "Triplematic" pump for mixing, metering, and dispensing up to 36,000 shots of 2-part resins per shift. H. V. Hardman Co., Inc. (A-277)

BAND HEATER FOR INJECTION MACHINES. Catalog sheets give specifications, diameters, voltages, watt densities and illustrations of line of electric heating bands designed for installation on injection cylinders. Thermel, Inc. (A-278)

INJECTION MOLDING PRESS. Illustrated 4-page brochure describes an automatic, 1/3 oz.-capacity injection press that operates at a speed of from 50 to 500 dry cycles per hour. Unit can be set up by a semi-skilled operator and placed into operation in 30 min. Simplomatic Mfg. Co. (A-279)

COMPRESSION MOLD SETS. Illustrated bulletin describes features of a line of compression mold sets that reduce the necessity for frequent changes in the feed mechanism height. For Stokes 15, 25, 50, and 75 ton capacity automatic molding presses, and similar machines. National Tool & Manufacturing Co. (A-280)

DEHUMIDIFIER FOR INJECTION MACHINES. Illustrated leaflet describes features of thermostatically-controlled hopper-dryer for small injection machines of up to 4-ounce capacity. Unit is available also for use with hygroscopic materials. Thoreson-McCosh, Inc. (A-281)

METALLIC SOAPS. 30-page booklet describes the features and properties of water-insoluble soaps, such as zinc and calcium stearates, for internal lubrication and plasticization of synthetic plastic molding powders. Lists uses, etc. Metasap Chemical Co. (A-282)

ELECTRIC CARTRIDGE HEATERS. Illustrated 4-page folder describes features of a line of cartridge heaters for applying up to 1000° F. of localized heat to work in areas requiring close thermal control, such as dies, platens, molds, and other types of processing equipment. Edwin L. Wiegand Co. (A-283)

DISPOSABLE WIPERS. 12-page illustrated brochure describes lines of high-absorbent cellulose wipers for wiping fine finishes and precision parts, plastic goggles, all-plastic boats, etc. Kimberly-Clark Corp. (A-284)

TESTING EQUIPMENT. Series of technical bulletins describe a machine for determining particle size distribution, a rotation viscometer, and alternate-stress testing machine, a hardening time meter, and a machine for determining the stability of semi-elastic plastics under pressure. Brinkman Instruments. (A-285)

MOLD AND DIE CAST DIE BASES. Illustrated catalog gives prices and specifications for special and standard mold and die cast die basis. Also lists available machining services. Columbia Engineering Co., Inc. (A-286)

RUBBERIZED ABRASIVES. Illustrated 8-page industrial catalog describes a line of rubberized abrasive wheels, points, blocks, sticks, and cones for deburring, smoothing, polishing, cleaning. Includes dimensions, applications, price list. Cratex Mfg. Co. (A-287)

PLASTIC STEEL. 12-page brochure pictures and describes plastic steel, available in putty and semi-viscous liquid form. The material is used for making of jigs, molds, models, fixtures, and for the rebuilding of machinery. Devcon Corp. (A-288)

TENSION CONTROL. Illustrated 16-page booklet describes features of lines of controlled tension winding and unwinding installations. Includes discussion of principles of center shaft winding. Hobbs Mfg. Co. (A-289)

TESTING EQUIPMENT. 12-page illustrated catalog describes abrasion testers for plastics, flammability-ignition testers, thickness, compression and recovery gages, custom instrumentation, etc. Custom Scientific Instruments, Inc. (A-290)

BIMETALLIC CYLINDERS. 16-page brochure describes the physical properties and performance features of company's bimetallic cylinders, used in extruders. Describes production facilities and available services. Industrial Research Labs., Div. Honolulu Oil Corp. (A-291)

COMPRESSION AND CAVITY MOLD SETS. 6-page catalog pictures and lists lines of cavity plate sets for compression and injection molding. Includes diagrams, specifications, prices. National Tool & Mfg. Co. (A-292)

INTENSIVE MIXER. 12-page illustrated brochure describes line of mix-mullers for uniform, intimate mixing and dispersion of plasticizers, pigments, etc., either dry or liquid. Capacities range up to 60 cu. ft. National Engineering Co. (A-293)

INJECTION MACHINES. 10-page brochure describes a line of self-contained, semi and fully automatic injection molding machines with capacities ranging from 1 to 13 oz. Negri Bossi & C. (A-294)

URETHANE FOAM MIXER-DISPENSER. 12-page instruction manual describes a push-button-controlled machine that meters, mixes and dispenses up to 20 lbs. of this company's uretnane resin-and-catalyst formulations per min. Nopco Chemical Co. (A-295)

THICKNESS GAGES. 34-page brochure describes non-contacting thickness gages for measurement of sheet material. Units measure weight per unit area of a moving web. Tracerlab, Inc. (A-296)

DATA AND CONTROL SYSTEMS. Illustrated 8-page brochure describes special industrial computers and data readout equipment for plastics processing operations. Units are said to reduce start-up and order change time, improve uniformity and save raw materials. Industrial Nucleonics Corp. (A-297)

DRUM TUMBLERS. 4-page folder presents specifications, prices for ¾-HP, 2-HP, and 3-HP disposable-drum model for dry color mixing. Lists specifications, prices. Injection Molders Supply. (A-298)

METERING & MIXING SYSTEMS. Technical data sheet describes automatic equipment for deaeration, proportional metering, mixing and metered dispensing of expoxies, polyesters, polyurethanes, polyamides, etc. Mitchell Specialty Div., Industrial Enterprises, Inc. (A-299)

AUTOMATIC INJECTION PRESS. Illustrated 4-page folder presents features and specifications of a ⅓-oz. capacity plastic injection press with automatic cycling from 50 to 500 dry cycles per hour. Simplomatic Mfg. Co. (A-300)

ELECTRIC HEATERS. Illustrated booklet presents 25 case studies describing the uses and advantages of "Chromalox" strip, ring, tubular and cartridge heating elements in plastics processing. Edwin L. Wiegand Co. (A-301)

TAKE-OFF UNIT. Booklet describes a take-off unit for extruders that operates with four heavy neoprene rolls at medium speeds of from 15 to 235 surface feet per min. Machine handles soft vinyl and polyethylene as well as rigid vinyl and Cycolac. H & T Machine Works. (A-302)

HYDRAULIC PRESSES. Folder illustrates line of compression, transfer, laminating and angle presses. Some models can exert pressures up to 10,000 tons. Karlton Machinery Corporation. (A-303)

TEMPERATURE REGULATORS. 4-page illustrated folder describes features and operation of new transistorized amplifier relays for precise temperature control in molding, extruding and other plastics processing operations. Brown Instrument Div., Minneapolis-Honeywell Regulator Co. (A-304)

PORTABLE HARDNESS TESTER. Data sheet describes a line of portable hardness testers for plastics and metals. Engineering data and prices are included. Barber-Colman Co. (A-305)

INDUSTRIAL WATER CHILLERS. 4-page brochure describes a line of air cooled chillers designed to furnish refrigerated water for industrial applications. Units provide for 100 per cent water recovery. Saren, Inc. (A-306)

TABLE MODEL VACUUM FORMERS. Illustrated 4-page brochure describes table model vacuum formers for product development and production. Units handle polyethylene, polystyrene, vinyl, acetate, butyrate and extruded acrylics. Plast-O-Craft Co., Inc. (A-307)

INJECTION MOLDING MACHINE. Data sheets describe features of an automatic 2½-oz. horizontal plastics injection molding press, that plasticizes over 30 lbs. per hr. Includes specifications, price data. The Van Dorn Iron Works Co. (A-308)

ROLL PRINTERS. Illustrated specification sheets presents construction and operational features of a line of printing machines for marking plastics and other materials in sheet, strip, or tube form. Markem Machine Co. (A-309)

TEMPERATURE MEASURING EQUIPMENT. Illustrated catalog describes this company's lines of industrial thermocouples, resistance bulbs, connectors, panels, switches, controllers, recorders, indicators, special instruments, etc. Thermo Electric Co., Inc. (A-310)

REINFORCED PLASTICS MOLDING PRESSES. Illustrated 7-page brochure describes 100-, 150- and 200-ton presses with maximum mold spaces 48 in. by 36 in., 60 in. by 48 in. and 84 by 60 in. The Hydraulic Press Mfg. Co. (A-311)

INJECTION MOLDING EQUIPMENT. Illustrated catalog gives specifications and prices for grinders, drum tumblers, automatic mold circulators, mold fillers, drying ovens, mold releases, etc. Injection Molders Supply Co. (A-312)

ELECTRIC CARTRIDGE HEATERS. Catalog sheet describes features of a line of electric cartridge heaters for stud heatng, stress-relieving, extruding metals, and metal forming. Includes specifications, prices. Edwin L. Wiegand Co. (A-313)

EXTRUDING EQUIPMENT. 6-page brochure describes a line of 1 to 8 in. hermoplastic extruders. Machines feature balanced heat control, quick-opening die gates, and torpedo-type screws. National Rubber Machinery Co. (A-314)

INJECTION MACHINE NOZZLES. 56-page catalog describes this company's tock replacement and special-purpose inection machine nozzles. Gives prices and ells how to measure for special nozzles. njection Molders Supply Co. (A-315)

CONSTANT TENSION CONTROL. -page brochure describes an automatic nd constant tension control for use on nwinders and rewinders, coaters, printers, embossers, slitters, extruders, sheeters, tc. Monkley Corp. (A-316)

MOLD TEMPERATURE CONTROL. Illustrated data sheet lists features and pecifications of a line of ¼ HP water or il circulators for automatic mold temperaure control. Includes prices. Injection Molders Supply Co. (A-317)

HYDRAULIC INJECTION PRESS. Illustrated 8-page booklet discusses construction and operational features of an all-hydraulic, shockless 28-oz. injection press which handles 165 lb. an hour. Includes specifications. National Automatic Tool Co., Inc. (A-318)

EXTRUSION EQUIPMENT. Folder contains diagrams and specifications of custom manufactured torpedo, forwarding, mixer and devolatizer, and feed extrusion screws. Johnson Mfg. Co. (A-319)

FILTER DUST COLLECTOR. 4-page brochure describes a suction-type, tubular cloth filter collector featuring a housing constructed of aluminum, and an automatic cleaning mechanism. Entoleter Division, The Safety Car Heating & Lighting Co., Inc. (A-320)

VACUUM COATERS. 14-page illustrated catalog describes equipment for metallizing plastics, metals, optics, electronics and wood. Includes units for mass production, development work and pilot production. NRC Equipment Corp., Sub. of National Research Corp. (A-321)

VACUUM FORMING MACHINES. Series of data sheets describe this company's line of vacuum forming machines for continuous production of thin-gage plastic articles, skin packaging and roll feed, production of props and scenery, laboratory testing, etc. Auto-Vac Co., Div. of National Tool Co. (A-322)

AUTOMATIC PRESSURE-FORMING. Illustrated 10-page reprint describes mass production of industrial parts and low-cost plastic packages by means of continuous automatic pressure forming. Tells how variables in operation cycle not only permit a variety of product features, but can enable filling and sealing to be done as well. Plaxall, Inc. (A-323)

INJECTION MOLDING MACHINES. Series of brochures describe this company's lines of automatic, hydraulically-operated injection molding machines. Units also available with pre-plasticizers. R. H. Windsor, Ltd. (A-324)

SYNTHESIZING SYSTEMS. 16-page illustrated brochure describes pilot plants, kettles, and auxiliary equipment for use in synthesizing and polymerizing, heating and cooling of synthetic resins, plastics, adhesives, varnishes, etc. The Patterson Foundry & Machine Co. (A-325)

FILTERS FOR HYDRAULIC UNITS. 12-page illustrated catalog describes this company's lines of sump and line type filters for oils, coolants and lubricants in hydraulic injection molding machines, hydraulic pumping units, etc. Marvel Engineering Co. (A-326)

PLASTICS GRANULATOR. Illustrated leaflet shows a scrap granulator with an automatic rapid-loading feature that returns granulated output to molding press hopper while material is still hot and dry. All specifications are included. Thoreson-McCosh, Inc. (A-327)

VERTICAL INJECTION MOLDING MACHINE. 4-page booklet describes 1- and 2-oz. vertical injection molding machines featuring a sliding table to facilitate loading, automatic cycling, automatic ejection and metered feed. Progressive Tool and Die. (A-328)

GRANULATORS. Illustrated brochure lists features and specifications of a line of high-based, all-steel granulators designed to handle all thermoplastic materials from .001-in. film to 11-in. solids. Alsteele Engineering Works, Inc. (A-329)

VISCOMETER-AMYLOGRAPH. Bulletin pictures and describes features of a viscometer-amylograph featuring a suspended stirrer sensing element, a 100% linear torque spring, and a bronze bottom stainless steel bowl. C. W. Brabender Instruments, Inc. (A-330)

GRANULATORS. Illustrated 5-page folder lists features of lines of easily cleanable, central and "beside the press," 1½ to 50 HP all-steel granulators which can be equipped with feed-roll choppers. Alsteele Engineering Works, Inc. (A-331)

CONVERTING MACHINERY. Illustrated 24-page booklet describes lines of plastics processing machinery. Includes coaters, laminators, slitter-rewinders, winders, printing presses, embossers, etc. Dilts Div., Black-Clawson Co. (A-332)

HOPPER-DRYER AND LOADER. 4-page illustrated brochure describes a hopper-dryer and automatic loader unit adaptable to any type of injection or extrusion machine setup. Unit permits uniform drying and preheating of material. Loader requires no compressed air source. Thoreson-McCosh, Inc. (A-333)

PLASTICS CONVEYOR. 4-page illustrated brochure describes a machine that conveys plastic particles of all sizes and shapes in smooth, sanitary, self-cleaning, one-piece metal troughs. Carrier Conveyor Corp. (A-334)

MOLD CEMENTS. 12-page booklet illustrates how to use gypsum cements for molds to be used in vacuum forming. Discusses proper methods of reinforcing vacuum forming molds. United States Gypsum Co. (A-335)

ELECTRONIC SEALING MACHINES. Illustrated literature describes line of electronic heat sealers and generators. Includes 2-post, 4-post and guillotine presses, a 250 watt rotary sealer, and generators with from 1 to 12 KW. output. Mayflower Electronic Devices. (A-336)

PHYSICAL PROPERTIES TESTER. 6-page illustrated folder describes an hydraulic, 47-lb., bench-type instrument for testing the physical properties of materials. Instrument releases power-driven testing machines for use where more detailed data is required. Truck Scale & Research Corp. (A-337)

VOID DETECTOR. 4-page brochure describes a line of machines for locating and recording minute holes or voids in any material which is electrically nonconducting. Viking Instruments, Inc. (A-338)

SIX-INCH EXTRUDER. 14-page catalog describes construction and operation features of a Reifenhauser six-inch extruder whose output ranges from 330 to 550 lbs./hr.. H. H. Heinrich Co. (A-339)

VERTICAL INJECTION PRESS. 4-page bulletin diagrams components and presents specifications of a 4- to 6-oz., 15 hp. vertical injection molding machine with a plasticizing capacity of 75 lb. per hour. Improved Machinery. (A-340)

PLASTIC KNOBS. 16-page catalog gives specifications for this company's lines of standard thermosetting instrument and control knobs, dials and assemblies, available from stock tooling. Standard Parts Div., Kurz-Kasch, Inc. (A-341)

GRANULATING MACHINES. 4-page illustrated folder describes a line of machines for producing an accurate, even granulation from a continuous web. Units work with web widths up to 4, 8, 12 and 18 inches. Into Roto. (A-342)

COATING AND IMPREGNATING. Bulletin describes low-cost roll coater for impregnating flexible web-fed film, sheeting, papers, and fabrics and for applying laminating adhesives. Diagrams depict flexibility of feed and roller arragements for single, double or reverse coating, to web laminating and impregnating. John Waldron Corp. (A-343)

EXTRUDERS. 12-page catalog gives specifications for a line of extruders, sizes 1½, 2, 2½, 3½, 4½, and 6 inches, with L/D ratios of 15:1, 21:1, 24:1, and 30:1. Sterling Extruder Corp. (A-344)

SMALL INJECTION MACHINES. Illustrated brochure presents features of a line of injection molding machines with capacities ranging from ⅓ to 1 oz. Machines handle all thermoplastics; make intricate electronic parts, novelties, etc. Newbury Industries, Inc. (A-345)

ROTARY MOLDING PRESSES. 4-page folder describes features of hopper-fed, 10 and 30-station automatic rotary molding presses for producing parts used in appliances, toys, instruments, etc. New England Butt Co. (A-346)

HIGH-SPEED CUTTERS. 8-page brochure describes this company's lines of automatic machines for cutting plastic materials, rubber, textiles, etc., without distortion, whether they are hot, cold, wet, dry, or sticky. Wink Div., The Motch & Merryweather Machinery Co. (A-347)

VARIABLE SPEED CONTROL. 8-page brochure describes operational features of variable speed drive and pneumatic control systems for pressure, temperature, humidity, and weight control, etc. U. S. Electrical Motors, Inc. (A-348)

ROTATIONAL MOLDING OF PLASTISOLS. Literature describes unit for rotational molding of vinyl plastisols. Machine consists of gas-operated oven with two 24- to 30-in. diameter mold holders mounted on a planetary drive. Accessory equipment also described. Mercury Conveyor, Inc. (A-349)

DIAMOND SAWS. Data sheet lists specifications for this company's diamond saws for sawing reinforced plastic laminates as epoxy, melamine, fiberglass, polyester, etc. W. F. Meyers Co., Inc. (A-350)

INJECTION MOLDING MACHINE. Illustrated 6-page booklet describes a hydraulic press designed to overcome problems of molding around inserts and cores. Press handles mold sizes of 6 by 5 by 5⅛ inches. Specifications listed. Newbury Industries, Inc. (A-351)

LABORATORY MOLDING MACHINE. Illustrated technical data sheet describes a plastic molder for laboratory research or prototype production. Machine molds all thermoplastics, including nylon; handles standard die sizes of 3 by 4 inches. Unex Laboratories, Div. of Nichols & Clark, Inc. (A-352)

PLASTICS PROCESSING EQUIPMENT. 4-page folder describes lines of German-made slitting and rewinding machines, granulators, laminators, plants for longitudinal and lateral stretching of film, etc. Inta-Roto Machine Co. (A-353)

LABORATORY EQUIPMENT. 4-page catalog gives specifications and prices for lines of laboratory polishing lathes and accessories, dust collectors, nameplate engravers, drill presses, UHF coaxial wavemeters, etc. Mico Instrument Co. (A-354)

PLASTICS MARKING MACHINES. 6-page brochure describes a hand operated machine for marking 500 to 1,000 articles/hr., and an air-driven, foot-operated press which works at double the former's rate. Includes specifications, special holding fixtures, related accessories. Kingsley Stamping Machine. (A-355)

POURED-IN-PLACE PLASTICS UNIT. Folder describes the "Nopcometer", an automatic unit for metering, mixing, and delivering up to 15 lb. of "Lockfoam" plastics formulations per minute. Plastics Div., Nopco Chem. Co. (A-356)

AUTOMATIC CONVEYORS. 4-page illustrated brochure describes lines of self-supporting conveyors, large-capacity standard and telescoping tube conveyors, proportional conveyors and bulk handling conveyors for all plastics materials. Whitlock Associates, Inc. (A-357)

DUST COLLECTORS. Illustrated 8-page brochure describes features, advantages of a line of units for continuous automatic filter cleaning. Air-pressure operated, they have no internal moving parts. Pulverizing Machinery Div., Metals Disintegrating Co., Inc. (A-358)

INJECTION MACHINES. Illustrated 40-page catalog describes line of injection presses with ⅓- to 1-oz. capacities. For small and specialty items, plastic molding over inserts, laboratory test samples, design and production, short or moderate runs. Newbury Industries, Inc. (A-359)

GRINDING WHEELS. Catalog describes lines of grinding wheels for plastic grooving, finishing, etc. Chicago Wheel & Mfg. Co. (A-360)

SURFACE PYROMETERS. Bulletin describes a line of thermoelectric instruments for indicating the temperature of flat and curved surfaces, and sub-surfaces of materials in a plastic or semi-plastic state. Cambridge Instrument Co., Inc. (A-361)

EXTRUDERS. Brochure describes lines of extruders, ranging from one-in. laboratory bench models to 15-in. machines with automatic die head clamps. Also lists available "packaged" insulations, dies and accessories. National Rubber Machinery Co. (A-362)

PNEUMATIC EQUIPMENT. Illustrated 20-page catalog describes features of lines of air filters, lubricators, regulators, and combination units. Includes specifications, engineering and operational data, performance characteristics. Industrial Div., Watts Regulator Co. (A-363)

PORTABLE PLASTIC MOLDER. Illustrated brochure describes an 88-lb. molding machine that works with all types of thermoplastics including nylon. Has ½-oz. or ¾-oz. shot capacity; production rate from 1 to 6 cycles/min. Unex Labs. Div., Nichols & Clark. (A-364)

INJECTION MOLDING MACHINES. Illustrated 4-page booklet presents construction and operational features of hand and power-operated, 10 and 15 gram injection molding machines. Includes specifications. Dowding & Doll, Ltd. (A-365)

ANTI-STATIC, CLEANING AGENT. Illustrated technical sheet describes an anti-static and cleaning agent for vinyl, polystyrene, nylon, and other plastic materials as well as glass, painted surfaces, fabrics, etc. Agent is said to be effective even under very dry and cold conditions. Chemical Development Corp. (A-366)

PROCESSING EQUIPMENT. 14-page brochure pictures and describes this company's facilities for designing and manufacturing embossers, laminators, flexographic and gravure presses, and other plastic film processing equipment. Lembo Machine Works, Inc. (A-367)

HYDRAULIC PRESSES. 4-page brochure describes hydraulic presses for molding, molding and laminating, polishing and laminating, embossing, and laboratory use. R. D. Wood Co. (A-368)

INJECTION PRESS. Illustrated folder describes and lists features of a 2¾-oz. injection press. Also describes this company's lines of compression presses. Clifton Hydraulic Press Co. (A-369)

POWER PLANE. Technical data sheet describes a power plane operated by direct drive, without gears, at speeds up to 21,000 RPM. Power tool is designed for fast, precise edge-work. The Black & Decker Mfg. Co. (A-370)

ROTARY PLASTIC MOLDING PROCESS. 4-page brochure describes the design and performance of this company's 10- and 30-station automatic rotary plastic molding presses. Single 30-station press can mold up to 90 separate plastic parts per min., with triple-cavity molds. New England Butt Co. (A-371)

EXTRUSION EQUIPMENT. 20-page booklet describes features of lines of extruders, pull-off units, conveyors, automatic cutters, drawing and winding take-up units, grinding mills and other extrusion equipment. Negri Bossi & C. (A-372)

HAND TOOLS, ACCESORIES. 12-page catalog describes and gives prices for this company's lines of portable hand tools, power grinders, mandrels, abrasive bands, saws, steel cutters, abraders, etc. Chicago Wheel & Mfg. Co. (A-373)

ELECTRONIC CONTROLS. Catalog gives prices and specifications for this company's lines of recorders, controllers, indicators, control accessories and combustion safeguards and accessories. Wheelco Instruments Div., Barber-Colman Co. (A-374)

PRESSES FOR REINFORCED PLASTICS. 4-page illustrated brochure describes line of electrically powered, automatic, semi-automatic or manually controlled presses for reinforced plastics with capacities from 25 to 600 tons. Specifications and data included. Dake Corp. (A-375)

FINISHING EQUIPMENT. 8-page illustrated catalog describes this company's lines of multi-spindle rotary finishers for finishing circular molded or machined parts; also a rotary edger for trimming, buffing and polishing melamine dinnerware. J. M. Nash Co., Inc. (A-376)

AUTOMATIC TEMPERATURE CONTROLS. Leaflet describes a line of temperature controls, steam traps, strainers, cooling controls, and a fully-automatic unit for controlling the face temperature of molds, rolls, cylinders and drums. Sarco Company, Inc. (A-377)

LABORATORY VACUUM FORMER. Data sheet describes portable, hand-operated vacuum forming machine suitable for laboratory use. Has 2-in. depth of draw and handles 10 by 10-in. sheet sizes. Precision Products. (A-378)

EPOXY METERING SYSTEMS. Brochure describes systems designed for proportional metering, mixing and metered dispensing of two-component reactive liquid resins of viscosities up to 500,000 cps at room temperature. Mitchell Specialty Div., Industrial Enterprises, Inc. (A-379)

STEEL MOLD BASE. 12-page illustrated catalog contains diagrams and specifications of company's line of steel mold bases and cavity sets. Prices included. Detroit Mold Engineering Co. (A-380)

HIGH SPEED PRESSES. Folder illustrates hydraulic presses designed for operations where high closing speed and a comparatively short pressure stroke are desirable. Includes cross-section diagram and specifications chart. Davidson-Kennedy Co. (A-381)

TEMPERATURE CONTROLS. 8-page illustrated booklet describes this company's lines of temperature controls and mounting wells. Includes operating specifications, dimensions, available modifications, etc. Fenwal, Inc. (A-382)

HEAT SEALERS AND HEATERS. 4-page illustrated brochure gives features and specifications of this company's dielectric heat sealers, industrial heating generators, portable high-frequency sealers, electronic quilters, etc. Dynatherm Div., Guild Electronics, Inc. (A-383)

LIQUID CHILLERS. Illustrated data sheet describes this company's line of self-contained, air- and water-cooled liquid chillers for cooling injection molding, embossing, extrusion and laminating equipment. VIC Mfg. Co. (A-384)

PREPLASTICIZING INJECTION PRESS. Bulletin describes an 80-oz. preplasticizing injection molding machine for production of minimum weight parts with controlled shot weight. Includes specifications, operational data, optional equipment. The Hydraulic Press Mfg. Co. (A-385)

STEAM GENERATORS. Series of brochures describes line of steam generators featuring a system whereby steam is generated by resistance of the boiler water to the passage of electricity between solid metal electrodes, thereby completely eliminating low water hazards. Pantex Mfg. Corp. (A-386)

HEATING UNITS. Brochure describes lines of heating units for use in extrusion die heaters, plastic spray guns, etc. Brochure also describes units used in the processing of reinforced plastics, plastic molding, etc. Thermel, Inc. (A-387)

ANTI-STATIC MOLD RELEASE. Catalog sheet describes an inert, invisible coating that eliminates static charges on dies, lubricates them, and prevents them from rusting. Lists prices. Optics Mfg. Corp. (A-388)

ELECTRONIC SEALING AND HEATING EQUIPMENT. Series of bulletins describe a line of machines for the electronic welding of rainwear, shower curtains, baby pants, inflated toys, upholstery, etc. Thermatron Div., Radio Receptor Co., Inc. (A-389)

ENGRAVED APPLICATOR ROLLS. Illustrated literature describes this company's engraved applicator rolls for the uniform application of color, plastic and adhesive. Gives features of rolls for use on aniline printing and gravure machines, also machines employing a doctor blade. Modern Engraving & Machine Co. (A-390)

THERMOFORMING MACHINES. Illustrated brochure describes lines of single- and double-stage machines for forming high density linear polyethylene and conventional rigid thermoplastic sheets. Aer-O-Flow Industries, Inc. (A-391)

DOUBLE ROTATION OVENS. 4-page illustrated brochure describes a double rotation oven for the molding of vinyl plastisols. Unit, which accommodates two aluminum mold plates simultaneously, features horizontal loading door and hinged access door. Brochure also describes auxiliary equipment. E. B. Blue Co. (A-392)

COMPRESSION MOLDING PRESSES. Illustrated 4-page folder describes construction and operational features of 25 and 50-ton, air-toggle powered automatic compression presses, for thermosetting materials and alkyd. Automatic Molding Machine Co. (A-393)

TOGGLE CLAMPS. Large catalog of myriad-used toggle clamps for industries such as automotive, aircraft, appliance, air-conditioning, radio and television, features types of clamps designed for any phase of plastics fabricating where positive, vise-like pressure and quick release are needed. Price list included. Detroit Stamping Company. (A-394)

HAND PYROMETERS. Illustrated 4-page brochure presents features of a line of portable hand pyrometers with attachments for a wide selection of temperature ndicating operations. Includes specifications, prices. West Instrument. (A-395)

DIELECTRIC WELDING. 16-page manual discusses principles of high frequency welding and heating of plastics materials. Examines operating procedures and equipment requirements for fabricating of vinyl sheet and plastic foams. Radio Receptor Co. (A-396)

EPOXY-HARDENER DISPENSER. Technical data sheet describes a dispenser hat meters and delivers desired quanities of epoxy resins and hardeners for applications in fiber glass fabricating operations. Unit eliminates hand-measuring of resins and hardeners. Auto-Air Industries, Inc. (A-397)

PACKAGED AUTOMATIC BOILER. Ilustrated catalog sheet describes a packaged automatic boiler constructed in both high and low pressure designs for both team or hot water service. Unit is available in 15, 20 and 30 H.P. sizes. Orr & Sembower, Inc. (A-398)

NDUSTRIAL HYDRAULIC OILS. 44-page illustrated guide book outline priniples of hydraulic systems. Explains important types of valves, pumps, motors, tc. Tells how to get the right oil and gives trouble-shooting pointers. Industrial Products Dept., Sun Oil Co. (A-399)

MOLD RELEASE AGENT. Handbook describes advantages of this company's elease agent in compression molding, esin potting and plastic casting, cold molded plastics, machining of plastics, tc. Price Driscoll Corp. (A-400)

EXTRUDERS. 6-page illustrated brohure describes a line of electrically eated extruders with capacities from 2 to 10 inches. Machines feature high, accurately zoned operating temperatures. John Royle & Sons. (A-401)

INJECTION MACHINES. Illustrated brochure describes a line of 16 to 20-oz. hydraulic machines with a plasticizing rate of 150 lbs./hr. and a maximum mold size of 23¾ in. by 36 in. Lombard Governor Corp. (A-402)

STEPLESS TEMPERATURE CONTROLLER. 12-page illustrated brochure describes a steady state temperature control featuring accurate positive temperature indication, multi-load reactors, the absence of vacuum tubes, etc. West Instrument Corp. (A-403)

HEAVY DUTY GRANULATORS. Brochure presents features of a line of heavy duty plastics granulators with capacities ranging from 500 to 2,500 pounds per hour. Ball & Jewell, Inc. (A-404)

HYDRAULIC PRESSES. 18-page catalog describes and illustrates this company's lines of hot plate, downward acting, and transfer molding presses; forming and drawing presses; etc. The French Oil Mill Machinery Co. (A-405)

MATERIAL CONVEYOR. 4-page illustrated folder describes a mechanical material conveyor for the automatic conveyance of molding powders, pellets and granules to molding presses and extruders. The Oaks Manufacturing Co., Inc., Subsid. Food Mach. & Chem. Corp. (A-406)

INFRA-RED ELEMENTS. 4-page illustrated brochure describes features and specifications of this company's infra-red elements for use in baking, coating, curing, drying, molding, polymerizing, preheating, etc. Industrial Process Div., Ampere Industries. (A-407)

SPRAY DECORATING EQUIPMENT. File folder contains illustrated literature on electroformed spray painting masks, several automatic spray painting machines, an automatic rotary wiping machine and a mask washing machine. Conforming Matrix Corp. (A-408)

VACCUM FORMING MOLDS. 4-page illustrated brochure discusses advantages of this company's sprayed metal molds for drape, plug and vacuum forming, especially of transparent plastics. Brochure also discusses advantages and disadvantages of plaster and resin molds. Metalmold Forming Co. (A-409)

GRANULATORS. 4-page illustrated brochure describes a line of all-steel, beside the press and batch granulators with capacities up to 400 lbs./hr. Ball & Jewell, Inc. (A-410)

INDUSTRIAL OVENS. Illustrated data sheet gives features, specifications and prices for a line of gas and electric cabinet ovens with maximum temperatures from 500° F. to 1,000° F. Grieve-Hendry Company, Inc. (A-411)

EXTRUDERS. Series of illustrated technical data sheets present features and specifications of this company's 1-, 1½-, 2-, 3-, 4½-, 6-, 8-, 10- and 12-in. variable speed extruders. Francis Shaw. (A-412)

VALVES. Catalog gives design and operating features of a wide variety of hydraulic, steam, and air valves. Sinclair-Collins Valve Co. (A-413)

LAMINATING PRESSES. Illustrated 4-page brochure describes features of lines of self-contained, hand-operated presses for laminating flat inserts, such as cards, tags, charts, photos, etc., at rates up to 150 per hour. Fred S. Carver. (A-414)

HOT STAMPING MACHINES. Technical bulletins describe air-powered and motor-driven hot stamping machines which are electrically heated and electrically or electronically controlled. Machines mark periphery of dials, rings, tubes, etc. The Acromark Co. (A-415)

SPRAY GUN FOR REINFORCED PLASTICS. Booklet describes spray gun-like tool that cuts glass groovings into desired lengths, and then applies it, together with mixed resin, catalyst and promotor, to mold. Deposition table included. Rand Development Corp. (A-416)

TOGGLE PRESS. 4-page illustrated release describes self-contained, semi-automatic compression and transfer toggle press, featuring a bar controller which automatically regulates phases of the molding cycle. F. J. Stokes Corp. (A-417)

COLOR TESTING. Illustrated 20-page booklet describes the operation of the Fadeometer, an electrically operated laboratory testing machine that determines the light fastness of colored materials through exposure to accelerated fading conditions. The Atlas Electric Devices Co. (A-418)

SLITTERS, REWINDERS, SHEETERS. 6-page folder illustrates and describes extensive line of slitters, rewinders, sheeters. Line includes drum-type sheeter, single rewind slitters, and a cutter for rigid plastics. Appleton Machine Co. (A-419)

INFRA-RED OVENS. Illustrated brochure describes a line of fused quartz electric radiant ovens designed for forming plastics. Corrosion and acid-resistant units provide heat up to 1,500°F. The Cleveland Process Co. (A-420)

PLASTICS CUTTERS. 4-page illustrated brochure describes machines for cutting round, rectangular or odd-shaped extrusions of any size with diameters up to 2-inches. Automatic units cut thin-wall tubing squarely without collapsing the tube. Foster & Allen, Inc. (A-421)

HYDRAULIC PRESSES. 28-page illustrated brochure describes this company's lines of plastic molding and special purpose presses. Standard platen sizes range from 20 by 20 inches to 50 by 50 inches. Hydraulic Press Div., The French Oil Mill Machinery Co. (A-422)

VACUUM METALLIZING. 24-page brochure describes techniques of vacuum metallizing plastic materials, outlines advantages and procedures, and gives details on a line of vacuum metallizing units with chamber diameters ranges from 24 to 72 inches. F. J. Stokes. (A-423)

SMALL LAMINATING PRESSES. 4-page illustrated brochure describes a line of hand-operated presses for laminating cards, passes, badges, photos, charts, tags, etc., with plastic at rates up to 150 pieces per hr. Fred S. Carver, Inc. (A-424)

CYLINDERS AND ROLLS. Illustrated brochure describes a line of wooden shells, rolls, and cores for processing web-fed plastics or rubber. Cylinder Mfg. Co. (A-425)

SIZING GRANULAR MATERIALS. Loose-leaf catalog binder contains data on several types of machines, orginally designed for grain and seed processing plants, that have application in the plastics field for the sizing of granular materials by length, width, and/or thickness differences. Hart-Carter Company. (A-426)

COMPRESSION PRESSES AND PLASTICS MILLS. Series of illustrated brochures describe lines of hydraulic presses for compression or transfer molding, laminating and polishing; also lines of plastics mills, including heavy duty crackers, washers and refiners. Erie Engine & Manufacturing Co. (A-427)

PLASTIC EXTRUSIONS, 2-COLOR EXTRUDER. Catalog lists and gives prices for this company's lines of belting, bindings, pipes, etc. Gives prices. Also describes a new vertical extruder that adds contrasting stripes to insulated wire, tubing, etc., for decorative or identification purposes. Thermoplastic Processes, Inc. (A-428)

DRAPE AND VACUUM FORMING MACHINE. Bulletin describes features of a line of automatic drape and vacuum forming machines with 15 in. drape strokes and mold areas from 20 in. by 30 in. to 48 in. by 72 inches. Comet Industries. (A-429)

COMPOUNDING MACHINE. Illustrated technical data sheet describes a machine for producing general purpose, high-impact and mineral-filled phenolic compounds in batch capacities up to 40 lbs., and in hourly capacities up to 1,200 lbs. Beardsley & Piper, Div. Pettibone Mulliken Corp. (A-430)

PLATEN PRESSES. 4-page illustrated brochure describes this company's lines of four column presses, with platens guided on pre-loaded ball-bearing sleeves. Operation is said to be almost entirely free of friction. Machine & Tool Div., Lempco Industrial, Inc. (A-431)

CABLE GAUGES. Specification bulletins describe design and operational features of a line of gauging equipment for continuous, non-contact measurement of insulated wire, extruded shapes, cable dimensions; and control of extrusion processes. Include performance data. Industrial Gauges Corp. (A-432)

TEMPERATURE CONTROLS. 4-page technical bulletin gives specifications, instructions for lines of transistorized amplifier relays used to control plastics processing, heat and cool loads, etc. Control range is −60° to +500° F. Minneapolis-Honeywell Regulator Co. (A-433)

SMALL INJECTION MACHINES. Illustrated brochure describes line of high-speed, automatic injection machines with capacities under 8 oz. Also describes "Duplimatic" machine for cord plug and insert molding. Moslo Machine Co. (A-434)

EXTRUDERS. 4-page illustrated brochure describes this company's line of extruders ranging in size from 1½ to 6 inches. Machines feature oversized feed opening to prevent clogging of the feed section; also oversize thrust assembly and screw support bearings for longer life. JMC (A-435)

EXTRUDERS. 4-page folder pictures and describes a line of five electrically heated, air-cooled extruders capable of achieving pressures up to 10,000 psi. Also discusses 6 in. by 13 in., 2-roll laboratory mill. Johnson Machinery Co. (A-436)

DIE-CUTTING PRESS. Technical bulletin describes this company's line of heat-assist, air-hydraulic die-cutting presses for sheet plastic, skin package cards. Cutting areas range up to 30 by 50 inches. Tronomatic Machine Mfg. Corp. (A-437)

HYDRAULIC CYLINDER CATALOG. 8-page catalog contains diagrams and specifications for line of high pressure hydraulic cylinders with 1½ to 12 in. bores that operate at over 2,000 p.s.i. Miller Fluid Power. (A-438)

PREFORMERS AND HYDRAULIC PRESSES. Illustrated 16-page brochure describes this company's preformers, available in capacities ranging from 30 to 125 tons; also its self-contained, semi-automatic compression and transfer presses ranging from 10- to 300-ton capacities. Logan Hydraulics, Inc. (A-439)

PLASTICS DRYERS. 4-page illustrated brochure discusses construction and operational features of a line of cabinet tray dryers for drying, preheating and low temperature baking of vinyl, nylon, and other plastic molding and extrusion powders. Includes specifications and diagrams. Lydon Bros., Inc. (A-440)

MARKING MACHINERY. 4-page brochure discusses lines of automatic, semi-automatic, and hand-fed marking presses operated by air, electric motor and by hand. For trade-marking, decorating, and identification. Also discusses services for marking in wide variety of colors, designs. Peerless Roll Leaf Co., Inc. (A-441)

PLATEN PRESSES. 6-page illustrated brochure describes lines of 4-column hydraulic presses for plastic molding, die try-out, general use. Power units range from 5 to 25 HP. Machine & Tool Div., Lempco Industrial, Inc. (A-442)

VARIABLE SPEED MACHINE DRIVES. 12-page illustrated booklet describes features of "Select-A-Spede" drives for powering extruders, calenders, laminators, and slitters and rewinders at precisely-controlled speeds. The Louis Allis Co. (A-443)

PLASTICS CUTTERS. Illustrated 4-page brochure describes this company's lines of machines for dicing sheet plastics, pelletizing plastics extruded in rods and cutting staple and flock. Units have a useable throat width of six inches. Taylor, Stiles & Co. (A-444)

TEMPERATURE INSTRUMENTS. Illustrated catalog shows a selected line of temperature recorders, controllers, indicators, control systems and accessories, and gives a brief description of the function of each instrument. West Instrument Corporation. (A-445)

SCRAP GRINDER. 12-page catalog pictures and describes design, construction, and operation of line of light and heavy duty materials-reducing hogs with output capacities ranging from 1,500 to 60,000 lbs. per hour. Includes specifications. Mitts and Merrill. (A-446)

HEAT SEALERS. Illustrated folder describes ½ to 30 kw. electronic heat sealing equipment. Lists typical fabricated products sealed by this equipment. Sealomatic Electronics Corp. (A-447)

ELECTROFORMED MOLDS. Data sheet describes the method by which electroformed molds for vacuum forming of plastics are made, outlines their advantages, and gives instructions on how such molds are prepared for actual use on vacuum forming equipment. T. V. Jay Co. (A-448)

MOLD TEMPERATURE CONTROLS. Brochure describes operation of a recirculating controlled-temperature water system for holding temperatures at the mold face to predetermined levels. Method is contrasted with other temperature control techniques. Industrial Manufacturing Corp. (A-449)

PARTS MARKING MACHINES. 6-page illustrated brochure describes lines of machines for marking, numbering and stamping of plastics, unhardened steel, brass and other metal and alloy pieces and parts. The Acromark Co. (A-450)

CONVEYORS FOR PLASTICS. 4-page folder pictures and describes lines of manually and automatically operated self-supporting and large capacity conveyors for all plastic materials. Includes special conveyors and attachments. Whitlock Associates, Inc. (A-451)

AUTOMATIC MOLDING METHODS. A thoroughly comprehensive 24-page booklet traces the origins, growth, and uses of fully automatic compression and injection molding equipment and discusses applications, cost, labor savings, and general advantages of automatic operation. F. J. Stokes Machine Company. (A-452)

MANUAL ON MOLD TEMPERATURE CONTROLS. 80-page manual consists of diagrams and text discussing mold discharge control, mold temperature control, plunger-slide oil cooling, control of quench or curing. Also gives specifications and features and applications of a full line of controlling devices and regulators. The Powers Regulator Co. (A-453)

MOLD TEMPERATURE CONTROL. Bulletin describes company's mold temperature control unit, suitable for injection molding, vacuum forming and sheet extrusion operations. Gives specifications and discusses features. Sterling, Inc. (A-454)

AUTOMATIC COMPRESSION PRESSES. Illustrated 12-page catalog describes features and gives specifications on line of 50, 75, 125, and 200-ton fully automatic compression molding presses with platen areas up to 30 by 24 inches and cycling speeds ranging from 8 to 11 seconds. F. J. Stokes Machine Co. (A-455)

FILM EXPANDER. Illustrated data sheet describes construction, special features and operation of an anti-wrinkle slat expander, suitable for installation on web processing equipment. Progressive Machine Co. (A-456)

MARKING MACHINES. Illustrated data sheets describe a quiet-operating, air-powered marking machine; an automatic marker that air-ejects the part after marking; and an automatic marker with Hopper feed. The Acromark Co. (A-457)

GENERATORS AND PRESSES. Illustrated data sheets describe a 1 KW generator with 2-post press and a 2 KW generator with 2-post press. Generators are single phase, 50-60 cycle. Presses are standard 2-post models with adjustable pressure control. Mayflower Electronic Devices, Inc. (A-458)

MOISTURE TESTER. Illustrated release describes design and operational features of a machine which assertedly weighs samples and delivers accurate readings within ±0.2%, in 6 minutes. C. W. Brabender Instruments, Inc. (A-459)

HYDRAULIC FLUIDS. 24-page booklet describes characteristics of hydraulic fluids and hydraulic systems and covers such subjects as viscosity recommendations, corrosion and rust prevention, reservoir requirements, and maintenance. Vickers, Inc. (A-460)

TIMERS AND COUNTERS. 8-page illustrated booklet discusses features and lists specifications of a line of reset, repeat-cycle, and special-purpose timers; counters, synchronous motors, closures, and control panels for automatic manufacturing. Eagle Signal Corp. (A-461)

PRECISION POWER TOOL. 4-page illustrated brochure describes a precision reciprocating hand machine for use in filing, lapping, scrapping, honing and polishing delicate and intricate pieces such as dies and molds. Engis Equipment Co. (A-462)

HOT STAMPING MACHINES. Illustrated catalog describes a line of air-powered hot stamping machines designed to mark up to 1,500 or more parts per hour. Machines mark tappered, conical-shaped and other types of dials, gages, and parts requiring calibrations; tube bases, etc. The Acromark Co. (A-463)

FILM PROCESSING EQUIPMENT. Catalog describes complete line of equipment for polishing, embossing, 1- and 2-color printing, inspection, etc. Gives features of single units that do one or a combination of these operations. Liberty Machine Co., Inc. (A-464)

HEAT SEALERS. Illustrated brochure describes this company's lines of automatic heat sealers. Units perform standard operations and will also produce three dimensional appliques and edges in different colors. Cosmos Electronic Machine Corp. (A-465)

EXTRUSION CUTTER. Literature describes a precision machine for cutting extruded tubing or shapes to exact length. Machine cuts up to 7,000 pieces per min. in lengths from 1/32 in. and diameters up to 1 inch. Foster & Allen, Inc. (A-466)

AUTOMATIC SLITTER. 8-page illustrated brochure describes an automatic slitter featuring a completely enclosed automatic spacer, a center carriage that moves by rack and gear on each rail, complete adjustability of the knife setting, etc. Lever Mfg. Co., Inc. (A-467)

PLASTIC MARKING EQUIPMENT. Loose-leaf catalog describes this firm's extensive line of hot stamping machines for branding, decorating, numbering, embossing, and engraving plastic and metal products. The Acromark Company. (A-468)

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3	33	63	93	123	153	183	213	243	273	303	333	363	393	423	453
4	34	64	94	124	154	184	214	244	274	304	334	364	394	424	454
5	35	65	95	125	155	185	215	245	275	305	335	365	395	425	455
6	36	66	96	126	156	186	216	246	276	306	336	366	396	426	456
7	37	67	97	127	157	187	217	247	277	307	337	367	397	427	457
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9	39	69	99	129	159	189	219	249	279	309	339	369	399	429	459
10	40	70	100	130	160	190	220	250	280	310	340	370	400	430	460
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27	57	87	117	147	177	207	237	267	297	327	357	387	417	447	477
28	58	88	118	148	178	208	238	268	298	328	358	388	418	448	478
29	59	89	119	149	179	209	239	269	299	329	359	389	419	449	479
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- Wire-coating machines 1131
- Wire wrapping machines 1131
- Wollastinite fillers 1110
- Woodflour fillers 1110

Resins, Molding Compounds, and Other Basic Materials

For list of distributors, see p. 1160

ADHESIVES

- A. *Acrylic*
- B. *Allyl*
- C. *Cellulose*
- D. *Coumarone-Indene*
- E. *Cyanoacrylate*
- F. *Epoxy*
- G. *Furan*
- H. *Isocyanate*
- I. *Melamine*
- J. *Nylon (Polyamide)*
- K. *Phenolic*
- L. *Polyester (Alkyds)*
- M. *Protein (Animal, casein, soybean, etc.)*
- N. *Resorcinol*
- O. *Rubber*
- P. *Silicate*
- Q. *Silicone*
- R. *Starch and Dextrins*
- S. *Styrene*
- T. *Urea*
- U. *Vinyl*

Acco Polymers, Brooklyn 22, N. Y. (A)
★Acme Resin Corp., Forest Park, Ill. (K)
Adhesive Products Corp., New York, N. Y. (A, C, D, F, H, I, J, K, L, M, N, O, P, S, T, U)
Adhesive Products, The, Inc., Albany 10, Calif. (C, M, O, R, U)
Aerojet-General Corp., Structural Plastics Div., Azusa, Calif. (F)
Alcylite Plastics & Chemical Corp., Newhall, Calif. (G, H, I, K, N, T)
Alkydol Laboratories, Inc., Cicero 50, Ill. (F, L, O)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (D, K, L, T)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (I, T)
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (F, O, S, U)
American Latex Products Corp., Hawthorne, Calif. (F, H, O, Q)
American-Marietta Co., Adhesive, Resin & Chemical Div., Seattle 5, Wash. (1, K, M, N, T)
American-Marietta Co., Booty Resineers Div., Newark, Ohio (I, K, T)
American Products Manufacturing Co., New Orleans 18, La. (A, C, O, P, S, U)
American Resin Corp., Chicago 13, Ill. (F, K, L)
Angier Adhesives Dept., Interchemical Corp. Finishes Div., Cambridge, Mass. (A, C, F, H, J, L, O, U)
Applied Plastics, Inc., El Segundo, Calif. (F, H, K)
Arabol Mfg. Co., The, New York 17, N. Y. (C, M, O, P, R, U)
Archer-Daniels-Midland Co., Minneapolis 2, Minn. (F)

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Aries Laboratories, Inc., Long Island City, N. Y. (F)
Armour & Co., Armour Alliance Industries, Alliance, Ohio (M, R, U)
Armstrong Cork Co., Lancaster, Pa. (A, D, F, J, K, N, O, R, S, U)
Armstrong Products Co., Warsaw, Ind. (F)
Atlas Mineral Products Co., Mertztown, Pa. (F)
Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (A, F, H, U)
B. B. Chemical Co., Cambridge 39, Mass. (H, J, K, N, O, R, U)
B. X. Plastics, Ltd., London, England (S)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (A, F, J, K, L, S, T, U)
★Bee Chemical Co., Chicago 33, Ill. (S)
★Belding Corticelli Industries, New York 18, N. Y. (J)
Biggs, Carl H., Inc., Santa Monica, Calif. (F, U)
Bloomingdale Rubber Co., Aberdeen Md. (F, K, O)
Bond Adhesives Co., Jersey City, N. J. (A, C, F, O, S, U)
Borden Chemical Co., The, New York 17, N. Y. (D, K, M, N, O, T, U)
Brilhart Plastics Corp., Mineola, N. Y. (A, C, F, H, L, O, S, U)
British Resin Products, Ltd., London W. 1, England (K, N, T, U)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (A, F, L, S, U)
Carboline Co., St. Louis 17, Mo. (F, O, U)
Carwin Co., The North Haven, Conn. (H)
★Catalin Corp. of America, New York 16, N. Y. (A, I, K, N, T)
Century Dispersions, Inc., Detroit 38, Mich. (K, O)
Chemical Coating & Engineering Co., Inc., Media, Pa. (D, F, H, J, K, O, U)
Chemical & Engineering Associates, Upper Darby, Pa. (A, F, H, K, O, U)
★Chemical Development Corp., Danvers, Mass. (A, C, F, O, S, U)
Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif. (A, C, D, F, H, I, K, L, O, Q, R, S, T, U)
Chemtron Fiber Glass Co. El Monte, Calif. (F, L)
★Clinton Co., The, Chicago 22, Ill. (C, F, L, S)
Clinton Corn Processing Co., Clinton, Iowa (R)
Compo Chemical Co., Waltham 54, Mass. (A, C, D, F, G, H, I, J, K, L, N, O, U)
★Continental-Diamond Fibre Corp., Sub. of The Budd Co., Newark, Del. (F, Q)
Cordo Chemical Corp., Norwalk, Conn. (A, F, K, U)
Corn Products Sales Co., New York 1, N. Y. (M, R)
★Cosden Petroleum Corp., Big Spring, Texas (S)
Daubert Chemical Co., Chicago 38, Ill. (O)
★Dayton Rubber Co., The, Dayton, Ohio (F, K, L, O)
Dennis Chemical Co., St. Louis 3, Mo. (A, C, F, K, O, U)
★Devcon Corp., Danvers, Mass. (F, O)
★Diamond Alkali Co., Cleveland 14, Ohio (P)
Diversified Technology, Inc., East Syracuse, N. Y. (K)
Dow Corning Corp., Midland, Mich. (Q)
Dreyfus, L. A., Co., S. Plainfield, N. J. (D, O)
★du Pont, E. I., de Nemours & Co., Inc., Wilmington 98, Del. (O, P, U)
★Durez Plastics Div., Hooker Chemical Corp., N. Tonawanda, N. Y. (G, K)
Dyna Therm Chemical Corp., Culver City, Calif. (A, F, K, N, O, U)
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (K, N)
Eastman Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (E)
Emerson & Cuming, Inc., Canton, Mass. (F, H, O, P)
Epoxylite Corp., El Monte, Calif. (F)
Eronel Industries, Hawthorne, Calif. (F, K, U)
★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (U)
Farrington Texol Corp., Walpole, Mass. (A, C, O, U)
Flexcraft Industries, Newark 5, N. J. (A, B, C, D, F, G, H, I, J, K)
Flexible Products Co., Marietta, Ga. (F, L, U)
Formica Corp., The, Cincinnati 32, Ohio (O, T)
Franklin Fibre-Lamitex Corp., Wilmington 99, Del. (A, C, F, J, K, L, M)
★Freeman Chemical Corp., Port Washington, Wis. (O)
Fuller, H. B., Co., St. Paul 2, Minn. (A, C, D, F, J, M, O, P, R T, U)
★Furane Plastics, Inc., Los Angeles 39, Calif. (F, G, H)
Garan Chemical Corp., Gardena, Calif. (A, F, L, U)
General Electric Co., Silicone Products Dept., Waterford, N. Y. (Q)
General Mills, Inc., Kankakee, Ill. (J)
General Plastics Mfg., Co., Tacoma 2, Wash. (A, F, H)
Goodrich, B. F., Indus. Products Co., Akron, Ohio (A, F, H, I, K, O, U)
★Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio (O)
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y. (U)
Gulton Industries, Inc., Metuchen, N. J. (F)
Hanley Plastics Co., St. Louis 17, Mo. (A, C, F, L)
Hardman, H. V., Co., Inc., Belleville 9, N. J. (F, K, O)
Hastings Plastics, Inc., Santa Monica, Calif. (F, J, K, L, U)
Hewitt, C. B., & Bros., Inc., New York 13, N. Y. (M, N, O, T, U)
Homalite Corp., The, Wilmington 4, Del. (F)

Houghton Laboratories, Inc., Olean, N. Y. (F, K)
Hughes Glue Co., Detroit 7, Mich. (A, B, C, D, F, J, K, M, O, P, R, S, T, U)
★Imperial Chemical Industries (Hyde) Ltd., Subs. Imperial Chemical Industries, Ltd., Cheshire, England (U)
★Imperial Chemical Industries, Ltd., Millbank, London, SW.1., England (A, C, H, K, L, O, T)
Industrial Plastic Fabricators, Norwood, Mass. (U)
Interchemical Corp., Finishes Div., Newark 5, N. J. (A, O, U)
Ions Exchange & Chemical Corp., New York 13, N. Y. (J)
Isochem Resins Corp., Providence 9, R. I. (F, L)
Jamestown Finishes, Inc., Jamestown, N. Y. (A, C, U)
Java Latex & Chemical Corp., New York 60, N. Y. (A, J, K, L, O, S, U)
★Johns-Manville, New York 16, N. Y. (C, O, P, U)
Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa. (N)
★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (S)
★Krieger Color & Chemical Co. Inc., Hollywood 38, Calif. (A, C, S, U)
Lami-Plast Products Co., Tampa 3, Fla. (F, H, L)
Lancaster Chemical Corp., Carlstadt, N. J. (F)
Landers Corp., The, Toledo 1, Ohio (O, U)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (F,L,O)
Lebec Chemical Corp., Paramount, Calif. (A, K, O, T, U)
Leon Chemical Industries, Inc., Warren, Mich. (A, F, L)
Magnolia Plastics, Inc., Chamblee, Ga. (F, L)
Manhattan Adhesives Corp., Brooklyn 22, N. Y. (A, F, K, L, M, N, O, P, Q, R, T, U)
★Marblette Corp., The, Long Island City 1, N. Y. (K)
★Marbon Chemical Div., Borg-Warner Corp., Washington, W. Va. (K, O)
McLeane, H. E., & Sons, St. Louis 10, Mo. (C, F, O)
Midland Adhesive & Chemical Corp., Ferndale 20, Mich. (A, C, D, F, H, K, L, M, O, P, R, S, T, U)
Minnesota Mining & Mfg. Co., Adhesive, Coating & Sealer Div., St. Paul 6, Minn. (F, O, U)
Miracle Adhesives Corp., Bellmore, L. I., N. Y. (A, C, D, F, L, O, U)
Mitchell Rand Mfg. Corp., New York 7, N. Y. (D, F)
Mobay Chemical Co., Pittsburgh 34, Pa. (H)
Modular Molding Corp., Burlington, N. J. (F, L)
Monite Waterproof Glue Co., Minneapolis 11, Minn. (M, T, U)
★Monsanto Chemical Co., Plastics Div., Springfield 2, Mass. (I, K, N, T, U)
Morningstar-Paisley, Inc., New York 19, N. Y. (A, K, M, O, P, R, T, U)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (U)
National Casein Co., Chicago 20, Ill. (I, M, N, O, T, U)
★National Polychemicals, Inc., Wilmington, Mass. (F, I, K, N, O, T, U)
National Starch & Chemical Corp., N. Y. 17, N. Y. (A, C, F, M, O, R, U)
★Naugatuck Chemical, Div. of U.S. Rubber Co., Naugatuck, Conn. (O)
New England Tape Co., Hudson, Mass. (F, U)
Nichols Products Co., Inc., Moorestown, N. J. (J)

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Nureco, Inc., Cranston 10, R. I. (F, L)
Ohio Adhesives Corp., New Philadelphia, Ohio (A, F, O)
★Omni Products Corp., New York 16, N. Y. (H, K, L, O, U)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (G, U)
Pelmor Laboratories, Inc., Newton, Pa. (G)
Pennsylvania Industrial Chemical Corp., Clairton, Pa. (D)
Perkins Glue Co., Lansdale, Pa. (I, K, M, N, R, T, U)
Permacel, New Brunswick, N. J. (A, B, F, K, L, M, O, R, S, U)
Philadelphia Quartz Co., Philadelphia 6, Pa. (P)
Pierce & Stevens Chemical Corp., Buffalo 3, N. Y. (A, C, F, O, S)
Plastex Laminates, Inc., Hialeah, Fla. (F, L, Q, S, T)
Plastic Center, Rochester 4, N. Y. (A, C, S, U)
Plastic Laminating Corp., Vauxhall, N. J. (C, U)
Plastics by Chapman, Richmond, Calif. (A, U)
Poly Resins, Sun Valley, Calif. (F)
Polymer Chemical Co., Cincinnati 12, Ohio (A, C, F, K, N, O, T, U)
★Polymer Corp. of Pa., Reading, Pa. (J)
Polymer Industries, Inc., Springdale, Conn. (A, F, J, M, O, P, R, S, U)
★Polypenco, Inc., Reading, Pa. (J)
Polyrez Co., Inc., Woodbury, N. J. (K)
Polyvinyl Chemicals, Inc., Peabody, Mass. (A, U)
Pyroxylin Products, Inc., Chicago 32, Ill. (A, C, D, J, S, U)
Quelcor, Inc., Chester, Pa. (U)
Rand Rubber Co., Brooklyn 16, N. Y. (O, U)
★Randolph Products Co., Carlstadt, N. J. (C, F, I, L, S, T, U)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (A, F, K, O, Q, U)
★Reichhold Chemicals, Inc., White Plains, N. Y. (F, H, I, K, L, M, N, T, U)
Ren Plastics, Inc., Lansing 9, Mich. (F)
Research Sales, Inc., Suffern, N. Y. (A, B, C, D, F, H, I, J, K, L, N, O)
★Reynolds Chemical Products Co., Whitmore Lake, Mich. (A, F, H, K, O, Q, U)
★Rohm & Haas Co., Philadelphia 5, Pa. (K, N, T)
Rubber & Asbestos Corp., Bloomfield, N. J. (A, C, D, F, H, J, K, L, N, O, S, U)
★Rubber Corp. of America, Hicksville, N. Y. (O)
Sartomer Resins, Inc., Philadelphia 4, Pa. (A, B, S)
Schjeldahl, G. T., Co., Northfield, Minn. (L)
Schramm Fiberglass Products, Inc. Chicago 18, Ill. (F, L)
Schwartz Chemical Co., Inc., Long Island City 1, N. Y. (A, C, O, S, U)
Servwell Products Co., Cleveland 3, Ohio (U)
Shamban, W. S., & Co., Culver City, Calif. (J)
Shannon, Alexander J., Co., The, New York 38, N. Y. (U)
★Shell Chemical Corp., New York 20, N. Y. (F)
Slomons Laboratories, Inc., Long Island City 1, N. Y. (C, O, R, S, U,)
Smooth-On Mfg. Co., Jersey City 4, N. J. (F)
★Standard Insulation Co., Inc., E. Rutherford, N. J. (F, K)
★Stanley Chemical Co., The, East Berlin, Conn. (F)
Steelcote Mfg. Co., St. Louis 3, Mo. (F, J)
Stein, Hall & Co., Inc., New York 17, N. Y. (M, O, R, U)
Stoner-Mudge Co., Pittsburgh 30, Pa. (A, F, H, K, U)
Synco Resins, Inc., Bethel, Conn. (F, K, O, U)
★Synthetic Products Co., Cleveland 12, Ohio. (F)
Synvan Corp., Wilmington 99, Del. (K, N, T)
Syracuse Plastic Molders, Syracuse 2, N. Y. (A, S)
Technicraft Co., Boston 34, Mass. (C)
UBS Chemical Corp., Cambridge 42, Mass. (O)
Union Paste Co., Hyde Park 36, Mass. (A, K, L, M, O, R, U)
United Shoe Machinery Corp., Boston 7, Mass. (A, C, D, H, J, L, N, O, S, U)
Valite Div. of Valentine Sugars, Inc., New Orleans, La., (K)
Varcum Chemical Corp., Niagara Falls, N. Y. (K)
Vereinigte Chemische Fabriken, Vienna, Austria (I, K, T)
Virginia Chemical Corp., Lynchburg, Va. (A, D, J, M, O, R, S, U)
★Watson-Standard Co., Pittsburgh 12, Pa. (A, F, K, U)
Witte & Sons, John H., Resin Div., Burlington, Iowa (D, F, H, L)
Xylos Rubber Co., Akron 1, Ohio (F, K, O, S, U)

CASEIN

B. X. Plastics, Ltd., London, England
Borden Chemical Co., The; N. Y. N. Y.
Erinoid, Ltd., London, England
★Harwick Standard Chemical Co., Akron 5, Ohio
Hewitt, C. B., & Bros., Inc., New York 13, N. Y.
Midland Adhesive & Chemical Corp., Ferndale 20, Mich.
★Monsanto Chemical Co., Plastics Div., Springfield 2, Mass.
Morningstar-Paisley, Inc., N. Y. N. Y.
National Casein Co., Chicago 20, Ill.
Perkins Glue Co., Lansdale, Pa.
Slomons Laboratories, Inc., Long Island City 1, N. Y.

CASTING MONOMERS AND RESINS

A. *Acrylic*
B. *Allyl Carbonate*
C. *Elastomeric Vinyl*
D. *Epoxy*
E. *Glyceryl Phthalate*
F. *Phenol-Formaldehyde*
G. *Polyester*
H. *Polyurethane*
I. *Rubber Latices*
J. *Silicone*
K. *Styrene*

Acco Polymers, Brooklyn 22, N. Y. (A)
★Acme Resin Corp., Forest Park, Ill. (F)
Adhesive Products Corp., New York 60, N. Y. (A, C, D, G, H, I, K)
Alframine Corp., Paterson 4, N. J. (A, D)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (G, H)
All-Tech Industries, Inc., Miami 68, Fla. (D, G)
American Alkyd Industries, Carlstadt, N. J. (G)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (G)
American-Marietta Co., Booty Resineers Div., Newark, Ohio (D, F)
Applied Plastics, Inc., El Segundo, Calif. (D, H)

Archer-Daniels-Midland Co., Minneapolis 2, Minn. (G, H)
Aries Laboratories, Inc., Long Island City, N. Y. (D, H)
Armstrong Products Co., Warsaw, Ind. (D)
B. B. Chemical Co., Cambridge 39, Mass. (H)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (C, G, K)
Biggs, Carl H., Co., Inc., Santa Monica, Calif. (D)
Borden Chemical Co., The, New York 17, N. Y. (A)
Brilhart Plastics Corp., Mineola, N. Y. (D, G, H, K)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (A, G, K)
Carwin Co., The, North Haven, Conn. (H)
★Catalin Corp. of America, New York 16, N.Y. (F)
Celanese Corp. of America, Chemical Div., New York 16, N. Y. (G)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (G)
Chase Chemical Corp., Pittsburgh 1, Pa. (H)
Chemical Coating & Engineering Co., Inc., Media, Pa. (C, D, H)
★Chemical Development Corp., Danvers, Mass. (D)
Chemical & Engineering Associates, Upper Darby, Pa. (C, D, G, H)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (G, I, K)
★Ciba Products Corp., Fair Lawn, N. J. (D)
★Clinton Co., The, Chicago 22, Ill. (I)
Cordo Chemical Corp., Norwalk, Conn. (D)
★Dayton Rubber Co., The, Dayton, Ohio (D, G, H, I)
Dennis Chemical Co., St. Louis 3, Mo. (C, D, I)
★Devcon Corp., Danvers, Mass. (D)
Disogrin Industries, Inc., Mt. Vernon, N. Y. (H)
Diversified Technology, Inc., East Syracuse, N. Y. (F)
★Dow Chemical Co., The, Midland, Mich. (A, D, I, K)
Dow Corning Corporation, Midland, Mich. (J)
★du Pont, de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, H, I)
★Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y. (F, G)
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (F)
Emerson & Cuming, Inc., Canton, Mass. (D, G, H, K)
Epoxylite Corp., El Monte, Calif. (D)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (A, D, G, H, I, J)
Flexcraft Industries, Newark 5, N. J. (A, C, D, E, F, G, H, K)
★Foster Grant Co., Inc., Leominster, Mass. (K)
★Freeman Chemical Corp., Port Washington, Wis. (G)
Garan Chemical Corp., Gardena, Calif. (G)
★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn. (D)
General Plastics Mfg. Co., Tacoma 2, Wash. (H)
Glasflex, Inc., Stirling, N. J. (G, B)
Glidden Co., The, Cleveland 14, Ohio (G)
Goodrich, B. F., Industrial Products Co., Akron 18, Ohio (D, I)
Hardman, H. V., Co., Inc., Belleville 9, N. J. (D)
Hastings Plastics, Inc., Santa Monica, Calif. (C, D, F, G, H)
Houghton Laboratories, Inc., Olean, N. Y. (D)
★Imperial Chemical Industries, Ltd., Millbank London, S.W.1, England (H)
Interchemical Corp., Finishes Div., Newark 5, N. J. (G)
Isochem Resins Corp., Providence 9, R. I. (D, G, U)
★Jones-Dabney Co., Louisville 8, Ky. (D)
★Koppers Co., Inc., Plastics Div., Pittsburg 19, Pa. (K)
Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa. (F)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (D)
Lebec Chemical Corp., Paramount, Calif. (A, F)
Leon Chemical Industries, Inc., Warren, Mich. (A, D, G, K)
Macromol Corp., The, Matawan, N. J. (K)
Magnolia Plastics, Inc., Chamblee, Ga. (D, G)
★Marblette Corp., The, Long Island City 1, N. Y. (D, F)
Mitchell Rand Mfg. Corp., New York 7, N. Y. (D)
Mobay Chemical Co., Pittsburgh 34, Pa. (H)
Mol Rez Div., American Petrochemical Corp., Minneapolis 18, Minn. (G)
★Monsanto Chemical Co., Plastics Div., Springfield 2, Mass. (K)
★National Polychemicals, Inc., Wilmington, Mass. (F)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (G, H, I)
New England Tape Co., Hudson Mass. (D)
★Nopco Chemical Co., N. Arlington, N. J. (H)
Nureco, Inc., Cranston 10, R. I. (D, G)
Ohio Adhesives Corp., New Philadelphia, Ohio (D, I)
★Omni Products Corp., New York 16, N. Y. (F)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (C)
Pelron Corp., Lyons, Ill. (H, K)
Peters Chemical Mfg. Co., Melrose Park, Ill. (A)
Pittsburgh Plate Glass Co., Paint Div., Pittsburgh 22, Pa. (G)
Plastex Laminates, Inc., Hialeah, Fla. (A, D, G, J, K)
Plastics by Chapman, Richmond, Calif. (A)
Plastics Enterprises, College Point, N.Y. (D)
Poly Resins, Sun Valley, Calif. (C, D, F, H)
Polymer Chemical Co., Cincinnati 12, Ohio (I)
Polymer Industries, Inc., Springdale, Conn. (D)
Polyplastex United, Inc., Union, N. J. (G)
★Reichhold Chemicals, Inc., White Plains, N. Y. (D, F, G, H)
Ren Plastics, Inc., Lansing 9, Mich. (D)
★Rohm & Haas Co., Philadelphia 5, Pa. (A, G)
Sartomer Resins, Inc., Philadelphia 4, Pa. (A)
Schramm Fiberglass Products, Inc., Chicago 18, Ill. (D, G)
★Shell Chemical Corp., New York 20, N. Y. (D)
Smooth-On Mfg. Co., Jersey City 4, N. J. (D)
Steelcote Mfg. Co., St. Louis 3, Mo. (D)
Synthetic Plastics, Newark, N.J. (G)
Synvan Corp., Wilmington 99, Del. (F)
Technicraft Co., Boston 34, Mass. (G)
Thiokol Chemical Corp., Trenton 7, N. J. (H)
Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y. (A, D, K)
★Union Carbide Plastics Co., Div. of Union Carbide Corp., New York 17, N. Y. (D)
U. S. Plastic Products Corp., Metuchen, N. J. (A)
★United States Gypsum Co., Chicago 6, Ill. (D)
Urethane Corp. of America, Medina, N. Y. (H)
Valite Div. of Valentine Sugars, Inc., New Orleans, La. (F)
Wasco Products, Inc., Cambridge 38, Mass. (A)
Witte, John H., & Sons, Resin Div., Burlington, Iowa (D, G, H)
Worbla, Ltd., Papiermuhle-Bern, Switzerland (K)
Xylos Rubber Co., Akron 1, O. (I)

CELLULOSE AND DERIVATIVES
(Flake)

A. *Cellulose*
B. *Cellulose Acetate*
C. *Cellulose Acetate Butyrate*
D. *Cellulose Nitrate*
E. *Cellulose Propionate*
F. *Ethyl Cellulose*
G. *Hydroxyethyl Cellulose*
H. *Methyl Cellulose*
I. *Sodium Carboxymethyl Cellulose*

★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y. (I)
B. X. Plastics Ltd., London, Eng. (D)
Bamberger, Claude P., Inc. Ridgefield Park, N. J. (B, C, E, F)
Blum, Paul, Co., Buffalo 10, N. Y. (D, F)
Brown Co., Boston 14, Mass. (A)
Buckeye Cellulose Corp., Memphis 8, Tenn. (A, I)
Celanese Corp. of America, Chemical Div., New York 16, N. Y. (B, E)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (B, E)
★Davis, Joseph, Plastics Co., Kearny, N. J. (B, D)
★Dow Chemical Co., The, Midland, Mich. (F, H)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (B, D, I)
Eastern Plastic Materials, Slatersville, R. I. (B)
Eastman Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (B)
★Eastman Chemical Products, Inc., Plastics Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (B, C, E)
Erie Plastics Co., Erie, Pa. (B, C)
Eronel Industries, Hawthorne, Calif. (C)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (B, C)
★Hercules Powder Co., Inc., Wilmington 99, Del. (A, D, F, G, I)
Mazzucchelli Celluloide S.p.a., Castiglione Olona, (Varese) Italy (D)
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y. (H, I)
★Muehlstein, H., & Co., New York 17, N. Y. (B, C, F)
Plastic Materials, Inc., Hicksville, N.Y. (B)
Poly-Cell Plastics Co., Smithtown, N. Y. (B)
Rayonier, Inc., New York 17, N. Y. (A)

★ Indicates Advertiser

★Reed Plastics Corp., Worcester 8, Mass. (B, C, E, F)

Southern Chemical Cotton Co., Chattanooga 5, Tenn. (A)

Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y. (G)

★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (G)

★Waljohn Plastics, Inc., Brooklyn 9, N. Y. (B)

Worbla, Ltd., Papiermuhle-Bern, Switzerland (D, I)

COATINGS

(See also Varnishes)

A. Acrylic
B. Alkyd
C. Cellulose
D. Epoxy
E. Furan
F. Melamine
G. Nylon (Polyamide)
H. Oil
I. Phenolic
J. Polyethylene
K. Rubber (Natural and Synthetic)
L. Silicone
M. Styrene
N. Urea
O. Vinyl
P. Special Coatings (e.g. Dial Insignia and Panel)

★Acme Resin Corp., Forest Park, Ill. (I)

Adhesive Products Corp., New York 60, N. Y. (A, B, C, D, F, G, I)

Alcylite Plastics & Chemical Corp., Newhall, Calif. (C, D, E, I, N)

Alkydol Laboratories, Inc., Cicero 50, Ill. (A, B, D, H, I, K)

★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (A, B, D, F, H, I, L, M, N)

★Allied Chemical Corp., Semet-Solvay Div., New York 6, N. Y. (J)

All-Tech Industries, Inc., Miami, 68, Fla. (D)

American Agile Corp., Bedford, Ohio (G, J)

American Alkyd Industries, Carlstadt, N. J. (B, H, I, M, N)

★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (B, F, N)

American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (K, O)

American Latex Products Corp., Hawthorne, Calif. (D, K)

American-Marietta Co., Adhesive, Resin & Chemical Div., Seattle 5, Wash. (N)

American-Marietta Co., Booty Resineers Div., Newark, Ohio (F, I, N)

American Products Mfg. Co., New Orleans 18, La. (A, C, K, M, O)

American Reinforced Plastics Co., Los Angeles 27, Calif. (I)

Applied Plastics, Inc., El Segundo, Calif. (D, I)

Arabol Mfg. Co., The, New York 17, N. Y. (O)

Archer-Daniels-Midland Co., Minneapolis 2, Minn. (B, D, H, I, O)

★Argenta Products Co., Garnerville, N. Y. (A, B, C, D, J, O)

Aries Laboratories, Inc., Long Island City, N. Y. (D)

Armitage, John L., & Co., Newark, N. J. (A, B, C, D, F, I, N, O)

Atlas Coatings Corp., Long Island City 1, N. Y. (A, B. C, D, O)

Atlas Mineral Products Co., Mertztown, Pa. (C, D, G, J, K, M, O)

★Auburn Plastics, Inc., Auburn, N. Y. (O)

Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (A, D, J, O)

B. B. Chemical Co., Cambridge 39, Mass. (A, D, K, O)

Barrett Varnish Co., Cicero 50, Ill. (A, B, C, D, F, H, I, M, N, O)

★Bee Chemical Co., Chicago 33, Ill. (A, B, C, D, F, I, J, M, N, O)

★Belding Corticelli Industries, New York 18, N. Y. (G)

Biggs, Carl H., Co., Inc., Santa Monica, Calif. (D)

Bischoff Chemical Corp., Ivoryton, Conn. (C, O)

Blum, Paul, Co., Buffalo 10, N. Y. (C)

Borden Chemical Co., The, New York 17, N. Y. (A, K, O)

Bradley & Vrooman Co., Chicago 16, Ill. (A, B, D, F, I, N, O)

Brilhart Plastics Corp., Mineola, N. Y. (D, M, O)

British Geon, Ltd., London W. 1, England (O)

Calresin Co., Div. of Knudsen Creamery, Los Angeles 39, Calif. (D, O)

Carboline Co., St. Louis 17, Mo. (A, D, E, I, K, L, O)

Carroll Products, Inc., Farmingdale, N. Y. (A, D, K, L, O)

★Catalin Corp. of America, New York 16, N. Y. (A, I)

Chemical Coating & Engineering Co., Inc., Media, Pa. (D, G, I, K)

★Chemical Development Corp., Danvers, Mass. (A, C, D, M, O)

Chemical & Engineering Associates, Upper Darby, Pa. (A, D, K, O)

Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif. (A, B, C, D, F, G, I, J, K, L, M, N, O)

★Chemical Products Corp., E. Providence 14, R. I. (O)

Chemtron Fiber Glass Co., El Monte, Calif. (D)

★Clinton Co., The, Chicago 22, Ill. (A, B, C, D, F, K, O)

Compo Chemical Co., Waltham 54, Mass. (A, B, C, D, M, G, I, K, O)

Connecticut Hard Rubber Co., New Haven 10, Conn. (L)

Cordo Chemical Corp., Norwalk, Conn. (D, H, O)

Crownoil Chemical Co., Long Island City 1, N. Y. (A, D, H)

Custom Coatings Co., Los Angeles 34, Calif. (A, D, G)

★Dayton Rubber Co., The, Dayton, Ohio (K, O)

Dennis Chemical Co., St. Louis 3, Mo. (A, C, D, F, I, K, O)

★Devcon Corp., Danvers, Mass. (D)

Dow Corning Corporation, Midland, Michigan (L)

★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, B, C, G, J, K, O)

★Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y. (A, I)

★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (C, I)

Dyna Therm Chemical Corp., Culver City, Calif. (A, B, D, I, K, L, O)

★Eastman Chemical Products, Inc., Plastics Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (C, J)

Electro-Technical Products Div., Sun Chemical Corp., Nutley 10, N. J. (D, H, I, L, N)

Emerson & Cuming, Inc., Canton, Mass. (D, M)

★Engineered Plastics, Inc., Gibsonville, N. C. (C, D, G, J)

Epoxylite Corp., El Monte, Calif. (D)

Erie Plastics Co., Erie, Pa. (G, J, O)

Eronel Industries, Hawthorne, Calif. (A, O)

Farbenfabriken-Bayer, A. G., Leverkusen, West Germany (K, L)

★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (O)

Flexcraft Industries, Newark 5, N. J. (A, B, C, D, I, M, O)

Flexible Products Co., Marietta, Ga. (D, O)

★Freeman Chemical Corp., Port Washington, Wis. (B, D, H, I, M)

Fuller, H. B., Co., St. Paul 2, Minn. (D, O)

★Furane Plastics, Inc., Los Angeles 39, Calif. (D, E, O)

Garan Chemical Corp., Gardena, Calif. (A, D, O)

★General Electric Co., Chemical Materials Dept., Pittsfield, Mass. (I)

★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn. (D)

General Mills, Inc., Kankakee, Ill. (G)

General Plastics Corp., Paterson, N. J. (G)

Glidden Co., The, Cleveland 14, Ohio (A, B, C, D, F, H, I, K, L, M, N, O)

Goodrich, B. F., Industrial Products Co., Akron 18, Ohio (D, I, K, O)

Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y. (K, O)

Gusmer, A., Inc., Woodbridge, N. J. (D)

Hanley Plastics Co., St. Louis 17, Mo. (A, B, C, F, H, I, L, M, N, O)

Hardman, H. V., Co. Inc., Belleville 9, N. J. (D)

Hastings Plastics, Inc., Santa Monica, Calif. (D, G, I, O)

Haynes, C. W., Laboratories, Inc., Springfield 4, Mass. (A, B, C, D, F, H, I, N, O)

Heresite & Chemical Co., Manitowoc, Wis. (I, K)

Homalite Corp., The, Wilmington 4, Del. (D)

Houghton Laboratories, Inc., Olean, N. Y. (D)

★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (B, C, D, F, G, H, I, K, M, N, O)

Industrial Plastic Fabricators, Norwood, Mass. (O)

Interchemical Corp., Finishes Div., Newark 5, N. J. (A, B, C, D, F, H, I, K, L, M, N, O)

★Irvin, Jewell & Vinson Co., The, Dayton 2, Ohio (P)

Isochem Resins Corp., Providence 9, R. I. (D, M)

Jamestown Finishes, Inc., Jamestown, N. Y. (A, B, C, D, F, I, N, O)

Jema-American, Inc., Newark 5, N. J. (A, B, C, D, F, I, M, N, O)

★Johns-Manville, N. Y. 16, N. Y. (K)

★Jones-Dabney Co., Louisville 8, Ky. (B, D)

Keystone Refining Co., Inc., Philadelphia 37, Pa. (A, B, C, D, F, H, L, M, N, O)

Kish Industries, Inc., Lansing 6, Mich. (D)

★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (J, K)

Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa. (D)

★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (A, B, C, G, H, I, M, N, O)

L & P Tool Co., Cincinnati, Ohio (O)

Lakeside Plastics Corp., Oshkosh, Wis. (A, B, C, D, F, H, I, J, K, L, N, O)

Lamex, Inc., Norcross, Ga. (J, M)

Lami-Plast Products Co., Tampa 3, Fla. (D)

Lancaster Chemical Corp., Carlstadt, N. J. (D)

★ Indicates Advertiser

Landers Corp., The, Toledo 1, Ohio (D, K, O)
★Lawter Chemicals, Inc., Chicago 45, Ill. (A, B, C, I)
Lebec Chemical Corp., Paramount, Calif. (I)
Leon Chemical Industries, Inc., Warren, Mich. (A, C, D, L)
Logo Div., Bee Chemical Co., Chicago 33, Ill. (A, B, C, D, F, G, I, K, M, N, O)
Magnolia Plastics, Inc., Chamblee, Ga. (D)
Marbek, Inc., Brooklyn 22, N. Y. (O)
★Marblette Corp., The, Long Island City 1, N. Y. (D, I)
Maynard Plastics, Inc., Salem, Mass. (J, K, O)
McCloskey Varnish Co., Philadelphia 36, Pa. (B, D, H, I)
McLeane, H. E., & Sons, St. Louis 10, Mo. (C, D, K, O)
★Metal & Thermit Corp., Rahway, N. J. (A, C, D, F, I, O)
★Michigan Chrome & Chemical Co., Detroit 13, Mich. (C, D, G, O)
Midland Adhesive & Chemical Corp., Ferndale 20, Mich. (A, B, C, D, H, I, K, M, N, O)
Minnesota Mining & Mfg. Co., Adhesive, Coating & Sealer Div., St. Paul 6, Minn. (K, O)
Miracle Adhesives Corp., Bellmore, L. I., N. Y. (D, O)
Mitchell Rand Mfg. Corp., New York 7, N. Y. (D)
Mol Rez Div., American Petrochemical Corp., Minneapolis 18, Minn. (B)
Monroe Sander Corp., The, Long Island City 1, N. Y. (A, B, C, D, F, H, I, J, K, L, M, N, O)
★Muehlstein, H., & Co., New York 17, N. Y. (O)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (A, O)
★National Polychemicals, Inc., Wilmington, Mass. (I, N)
National Polymer Products, Inc., Reading, Pa. (C, D, G, J, O)
National Starch & Chemical Corp., N. Y. 17, N. Y. (A, C, O)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (K, O)
New England Tape Co., Hudson, Mass. (D, O)
Nikolas & Co., G. J., Inc., Bellwood, Ill. (A, B, C, D, F)
Ohio Adhesives Corp., New Philadelphia, Ohio (D, K)
Para Products Div., Foundry Rubber, Inc., Washington 16, D. C. (K)
Parcloid Chemical Co., Midland Park, N. J. (O)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (N, O)
Permacel, New Brunswick, N. J. (D)
Pierce & Stevens Chemical Corp., Buffalo 3, N. Y. (A, B, C, D, F)
Pittsburgh Plate Glass Co., Paint Div., Pittsburgh 22 Pa. (A, B, H, L, M)
Plastex Laminates, Inc., Hialeah, Fla. (A, D, F, L, M)
Polykote, Inc., Cleveland 3, Ohio (C, D, O)
Polymer Chemical Co., Cincinnati 12, Ohio (A, C, D, I, K, O)
Polymer Industries, Inc., Springdale, Conn. (D, K, O)
★Polypenco, Inc., Reading, Pa. (C, D, G, O)
Protective Treatments, Inc., Dayton 3, Ohio (A, C, O)
Prufcoat Laboratories, Inc., Cambridge 42, Mass. (A, B, D, I, L, M, O)
Putnam Chemical Corp., Beacon, N. Y. (O)

Pyroxylin Products, Inc., Chicago 32, Ill. (A, B, C, D, F, K, M, N, O)
Quelcor, Inc., Chester, Pa. (O)
Raffi & Swanson, Inc., Wilmington, Mass. (A, B, C, D, F, I, M, N, O)
★Randolph Products Co., Carlstadt, N. J. (A, B, C, D, F, L, M, N, O)
Rand Rubber Co., Brooklyn 16, N. Y. (K, O)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (A, D, I, K, L, O)
Red Spot Paint & Varnish Co., Inc., Evansville 8, Ind. (A, B, C, D, F, H, I, K, L, M, N, O)
Ren Plastics, Inc., Lansing 9, Mich. (D)
Research Sales, Inc., Suffern, N. Y. (A, B, C, D, F, G, H, I, K, L, M, N, O)
Rexton Finishes, Inc., Irvington 11, N. J. (A, B, C, D, F, H, I, M, N, O)
Ridge Printing Co., Inc., Ridgefield, N. J. (O)
Rubber & Asbestos Corp., Bloomfield, N. J. (K)
★Rubber Corp. of America, Hicksville, N. Y. (K, O)
St. Regis Paper Co., Panelyte Div., Yonkers, N. Y. (J)
Santa Barbara Plastics, Sub. of Narmco Industries, Inc., Goleta, Calif. (O)
Sartomer Resins, Inc., Philadelphia 4, Pa. (A)
Schenectady Varnish Co., Schenectady 1, N. Y. (B, G, H, I)
Schori Process Corp., Long Island City 1, N. Y. (D)
Schramm Fiberglass Products, Inc., Chicago 18, Ill. (D)
Schwartz Chemical Co., Inc., Long Island City 1, N. Y. (A, B, C, D, F, I, M, N, O)
Shanco Plastics & Chemicals, Inc., Tonawanda, N. Y. (I, M, O)
Smooth-On Mfg. Co., Jersey City 4, N. J. (D)
Solvic S. A., Brussels 4, Belgium (O)
Spraylat Corp., New York 16, N. Y. (A, K, O)
★Stanley Chemical Co., The, East Berlin, Conn. (A, B, C, D, F, H, I, L, M, N, O)
Steelcote Mfg. Co., St. Louis 3, Mo. (A, B, C, D, F, G, H, I, K, L, N, O)
Stoner-Mudge Co., Pittsburgh 30, Pa. (D, F, H, I, K, N, O)
★Sullivan Varnish Co., Chicago 22, Ill. (A, B, C, D, F, H, I, K, M, N, O)
Sundure Paint Corp., Syracuse 4, N. Y. (A, B)
Sun Steel Co., Chicago 36, Ill. (O)
★Synthetic Products Co., Cleveland 12, Ohio (D)
Truscon Laboratories, Div. of Devoe & Reynolds Co., Inc., Detroit 11, Mich. (B, D, H, L)
UBS Chemical Corp., Cambridge 42, Mass. (K)
Union Carbide Corp., Silicones Div., New York 17, N. Y. (L)
Valite Div. of Valentine Sugars, Inc., New Orleans, La. (I)
Varcum Chemical Corp., Niagara Falls, N. Y. (I)
Vereinigte Chemische Fabriken, Vienna, Austria (F)
★Vernon Specialties, Inc., N. Tarrytown, N. Y. (A, B, C, D, F, G, I, J, L, M, N, O)
★Watson-Standard Co., Pittsburgh 12, Pa. (A, B, D, F, G, H, I, K, L, M, N, O)
Western Coating Co., Royal Oak, Mich. (C, O)
Witte, John H., & Sons, Resin Div., Burlington, Iowa (B, D, I)
Xylos Rubber Co., Akron 1, O. (K, O)

EMULSIONS AND DISPERSIONS

A. Acrylic
B. Alkyd
C. Allyl
D. Cellulose
E. Coumarone-Indene
F. Fluorocarbons
G. Furan
H. Isocyanate
I. Melamine
J. Nylon
K. Phenolic
L. Polyester
M. Polyethylene
N. Protein
O. Rubber
P. Resorcinol
Q. Styrene
R. Vinyl

Acco Polymers, Brooklyn 22, N. Y. (A)
★Acheson Dispersed Pigments Co., Unit of Acheson Industries, Philadelphia 3, Pa. (L, O, Q, R)
Adhesive Products Corp., New York 60, N. Y. (A, B, D, E, H, I, J, K, L, O, Q)
Alkydol Laboratories, Inc., Cicero 50, Ill. (A, B)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (B, E, I, K, L)
All-Tech Industries, Inc., Miami 68, Fla. (L)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (B)
American Latex Prdoucts Corp., Hawthorne, Calif. (O)
American Marietta Co., Adhesive, Resin & Chemical Div., Seattle 5, Wash. (K)
American-Marietta Co., Booty Resineers Div., Newark, Ohio (A, K)
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y. (R)
Arabol Mfg. Co., The, New York 17, N. Y. (R)
★Argenta Products Co., Garnerville, N. Y. (A, B, D, L, Q, R)
Armour & Co., Armour Alliance Industries, Alliance, Ohio (N, R)
Armstrong Cork Co., Lancaster, Pa. (A, R)
Atlas Coatings Corp., Long Island City 1, N. Y. (R)
★Auburn Plastics, Inc., Auburn, N. Y. (R)
Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (A, H, R)
B. B. Chemical Co., Cambridge 39, Mass. (O)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (A, Q, R)
Borden Chemical Co., The, New York 17, N. Y. (A, E, O, Q, R)
Bradley & Vrooman Co., Chicago 16, Ill. (A, O, R)
Brilhart Plastics Corp., Mineola, N. Y. (L)
British Geon, Ltd., London W. 1, England (R)
British Resin Products, Ltd., London W. 1, England (R)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (R)
Carboline Co., St. Louis 17, Mo. (R)
★Cassella Farbwerke Mainkur, A. G., Frankfurt/Main, West Germany (I)
★Catalin Corp. of America, New York 16, N. Y. (A, K)

★ Indicates Advertiser

Celanese Corp. of America, Chemical Div., New York 16, N. Y. (A, R)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (A, R)
Chase Chemical Corp., Pittsburgh 1, Pa. (H)
Chemical Coating & Engineering Co., Inc., Media, Pa (H, O)
Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif. (B, E, L, M, Q)
★Chemical Products Corp., E. Providence 14, R. I. (R)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (A, Q, R)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Cleveland, Ohio (R)
★Cooke Color & Chemical Co., Hackettstown, N. J. (O, Q, R)
Corn Products Sales Co., New York 1, N. Y. (N)
Dennis Chemical Co., St. Louis 3, Mo. (O, R)
Dewey & Almy Chemical Co., Div., W. R. Grace & Co., Cambridge 40, Mass. (Q, R)
★Dow Chemical Co., The, Midland, Mich. (A, Q, R)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (F, O, R)
★Durez Plastics Div., Hooker Chemical Corp., N. Tonawanda, N. Y. (K, L)
Emerson & Cuming, Inc., Canton, Mass. (R)
Erie Plastics Co., Erie, Pa. (R)
Eronel Industries, Hawthorne, Calif. (R)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (A, H, O)
★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (R)
Firestone Plastics Co., Pottstown, Pa. (A, O, Q, R)
Flexcraft Industries, Newark 5, N. J. (A, R)
Flexible Products Co., Marietta, Ga. (R)
★Foster Grant Co., Inc., Leominster, Mass. (J, Q)
★Freeman Chemical Corp., Port Washington, Wis. (B, R)
Fuller Co., H. B., St. Paul 2, Minn. (O, R)
General Plastics Mfg. Co., Tacoma 2, Wash. (H)
★Glidden Co., The, Cleveland 14, Ohio (A, B, D, H, I, L, N, Q)
★Goodrich, B. F., Chemical Co., Cleveland 15, Ohio (R)
Goodrich, B. F., Industrial Products Co., Akron 18, Ohio (K, O, R)
★Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio (O, Q)
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y. (R)
★Harwick Standard Chemical Co., Akron 5, Ohio (E, Q)
Hewitt, C. B., & Bros., Inc., New York 13, N. Y. (R)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (A, B, F, R)
Industrial Plastic Coating Corp., Clifton, N. J. (F)
Interchemical Corp., Finishes Div., Newark 5, N. J. (L)
Isochem Resins Corp., Providence 9, R. I. (L)
Joclin Mfg. Co., Wallingford, Conn. (F)
★Jones-Dabney Co., Louisville 8, Ky. (R)
Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa. (P)
★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (M, Q)
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (A, B, D, J, L, O, Q, R)

Lancaster Chemical Corp., Carlstadt, N. J. (O)
Landers Corp., The, Toledo 1, Ohio (O, R)
Leon Chemical Industries, Inc., Warren, Mich. (A)
★Marbon Chemical Div., Borg-Warner Corp., Washington, W. Va. (Q)
McCloskey Varnish Co., Philadelphia 36, Pa. (R)
★Michigan Chrome & Chemical Co., Detroit 13, Mich. (R)
Midland Adhesive & Chemical Corp., Ferndale 20, Mich. (A, B, D, H, K, L, N, O, Q, R)
Minnesota Mining & Mfg. Co., Chemical Div., St. Paul 6, Minn. (F)
★Monsanto Chemical Co., Plastics Div., Springfield 2, Mass. (I, K, Q, R)
Morningstar-Paisley, Inc., New York 19, N. Y. (A, N, O, R)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (R)
National Starch & Chemical Corp., N. Y. 17, N. Y. (A, O, R)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (O, R)
New England Tape Co., Hudson, Mass. (R)
Ohio Adhesives Corp., New Philadelphia, Ohio (O)
★Omni Products Corp., N. Y. N. Y. (K)
Parcloid Chemical Co., Midland Park, N. J. (R)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (R)
Pelmor Laboratories, Inc., Newtown, Pa. (O)
Pennsylvania Industrial Chemical Corp., Clairton, Pa. (E)
Permacel, New Brunswick, N. J. (R)
Pierce & Stevens Chemical Corp., Buffalo 3, N. Y. (O, R)
★Plastics Engineering Co., Sheboygan, Wis. (K)
Polykote, Inc., Cleveland 3, Ohio (R)
Polymer Chemical Co., Cincinnati 12, Ohio (K, O, R)
Polyrez Co., Inc., Woodbury, N. J. (K)
Polytex Industrial Finishes Corp., Affiliate of Atlas Coatings Corp., Long Island City, New York (R)
Polyvinyl Chemicals, Inc., Peabody, Mass. (A, Q, R)
Putnam Chemical Corp., Beacon, N. Y. (Q, R)
Quelcor, Inc., Chester, Pa. (R)
★Reichhold Chemicals, Inc., White Plains, N. Y. (A, B)
Research Sales, Inc., Suffern, N. Y. (A, B, O, Q, R)
★Rohm & Haas Co., Philadelphia 5, Pa. (A)
★Rubber Corp. of America, Hicksville, N. Y. (O)
Sartomer Resins, Inc., Philadelphia 4, Pa. (A, C)
Schori Process Corp., Long Island City 1, N. Y. (L)
Shanco Plastics & Chemicals, Inc., Tonawanda, N. Y. (Q, R)
Shawinigan Resins Corp., Springfield 1, Mass. (R)
Smith, J. Lee, & Co., Inc., New York 38, N. Y. (A, B, G, L, Q, R)
Spraylat Corp., N. Y., N. Y. (A, R)
★Stanley Chemical Co., The, East Berlin, Conn. (A, B, I, L, Q, R)
Stein, Hall & Co., Inc., New York 17, N. Y. (A, O, R)
Stoner-Mudge Co., Pittsburgh 30, Pa. (A, R)
Sundure Paint Corp., Syracuse 4, N. Y. (A)
Synco Resins, Inc., Bethel, Conn. (K, R)
Technicraft Co., Boston 34, Mass. (R)
Thiokol Chemical Corp., Trenton 7, N. J. (O)

Tri-Point Plastics, Inc., Albertson, N. Y. (F)
Truscon Laboratories, Div. of Devoe & Reynolds Co., Inc., Detroit 11, Mich. (A, R)
UBS Chemical Corp., Cambridge 42, Mass. (A, Q)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (F, K)
★Union Carbide Plastics Co., Div. of Union Carbide Corp., New York 17, N. Y. (R)
Velsicol Chemical Corp., Chicago 11, Ill. (E)
★Watson-Standard Co., Pittsburgh 12, Pa. (A, Q, R)
Witte, John H., & Sons, Resin Div., Burlington, Iowa (A, H, K, L)
Xylos Rubber Co., Akron 1, Ohio (O)

LAMINATING RESINS, LOW-PRESSURE

A. Acrylic
B. Epoxy
C. Phenolic
D. Polyester
E. Silicone

Adhesive Products Corp., New York 60, N. Y. (A, B, C, D, E)
Alkydol Laboratories, Inc., Cicero 50, Ill. (B, C, D)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (C, D)
All-Tech Industries, Inc., Miami 68, Fla. (C)
American Alkyd Industries, Carlstadt, N. J. (D)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (D)
American Latex Products Corp., Hawthorne, Calif. (B)
American-Marietta Co., Adhesive, Resin & Chemical Div., Seattle 5, Wash. (C)
American-Marietta Co., Booty Resineers Div., Newark, Ohio (C)
American Reinforced Plastics Co., Los Angeles 27, Calif. (C)
American Resin Corp., Chicago 13, Ill. (B, C, D)
Applied Plastics, Inc., El Segundo, Calif. (B, C)
Archer-Daniels-Midland Co., Minneapolis 2, Minn. (B, D)
Aries Laboratories, Inc., Long Island City, N. Y. (B)
Armstrong Products Co., Warsaw, Ind. (B)
Atlas Powder Co., Wilmington 99, Del. (D)
Biggs, Carl H., Co., Inc., Santa Monica, Calif. (B)
Brilhart Plastics Corp., Mineola, N. Y. (B, D)
British Resin Products, Ltd., London W. 1, England (C, D)
★Catalin Corp. of America, New York 16, N. Y. (A, C)
Celanese Corp. of America, Chemical Div., New York 16, N. Y. (D)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (D)
Chemical & Engineering Associates, Upper Darby, Pa. (B)
Chemical Coating & Engineering Co., Inc., Media, Pa. (B)
★Chemical Development Corp., Danvers, Mass. (B)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (D)
★Ciba Products Corp., Fair Lawn, N. J. (B)

★ Indicates Advertiser

Connecticut Hard Rubber Co., New Haven 10, Conn. (E)
Dennis Chemical Co., St. Louis 3, Mo. (B)
★Devcon Corp., Danvers, Mass. (B)
Dow Corning Corporation, Midland, Mich. (E)
★Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y. (C, D)
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (C)
Emerson & Cuming, Inc., Canton, Mass. (B, D)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (B, E)
Flexcraft Industries, Newark, N. J. (A, B, C, D)
★Freeman Chemical Corp., Port Washington, Wis. (D)
Fuller, H. B., Co., St. Paul, Minn. (B)
★Furane Plastics, Inc., Los Angeles 39, Calif. (B)
★General Electric Co., Chemical Materials Dept., Pittsfield, Mass. (C)
★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn. (B)
★Glidden Co., The, Cleveland 14, Ohio (D)
Hastings Plastics, Inc. ,Santa Monica, Calif. (B, C, D)
Houghton Laboratories, Inc., Olean, N. Y. (B)
Interchemical Corp., Finishes Div., Newark 5, N. J. (D)
Isochem Resins Corp., Providence 9, R. I. (B, D)
★Jones-Dabney Co., Louisville 8, Ky. (B)
Kish Industries, Inc., Lansing 6, Mich. (B, D)
Lami-Plast Products Co., Tampa 3, Fla. (B, D)
Lawrence Adhesive & Chemical Co., Lawrence, Mass. (B)
Lebec Chemical Corp., Paramount, Calif. (C)
Leon Chemical Industries, Inc., Warren, Mich. (B, D)
Magnolia Plastics, Inc., Chamblee, Ga. (B, E)
Mol Rez Div., American Petrochemical Corp., Minneapolis 18, Minn. (D)
Morningstar-Paisley, Inc., New York 19, N. Y. (A, C)
★National Polychemicals, Inc., Wilmington, Mass. (C)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (D)
Ohio Adhesives Corp., New Philadelphia, Ohio (B)
★Omni Products Corp., New York 16, N. Y. (C, D)
Permacel, New Brunswick, N. J. (B)
Pittsburgh Plate Glass Co., Paint Div., Pittsburgh 22, Pa. (D)
Plastex Laminates, Inc., Hialeah, Fla. (A, B, D, E)
Plastic Service Corp., New York 10, N. Y. (A, B, C, D)
★Plastics Engineering Co., Sheboygan, Wis. (C)
Polyrez Co., Inc., Woodbury, N. J. (C)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (B, C, E)
★Reichhold Chemicals, Inc., White Plains, N. Y. (B, C, D)
Ren Plastics, Inc., Lansing 9, Mich. (B)
★Rohm & Haas Co., Philadelphia 5, Pa. (D)
Sartomer Resins, Inc., Philadelphia 4, Pa. (A)
Schenectady Varnish Co., Schenectady 1, N. Y. (C, D)
Schori Process Corp., Long Island City 1, N. Y. (D)
★Shell Chemical Corp., New York 20, N. Y. (B)
Smooth-On Mfg. Co., Jersey City 4, N. J. (B)
Steelcote Mfg. Co., St. Louis 3, Mo. (B)
Synco Resins, Inc., Bethel, Conn. (C)
Synvan Corp., Wilmington 99, Del. (C)
Technicraft Co., Boston 34, Mass. (D)
★Union Carbide Corp., Silicones Div., New York 17, N. Y. (E)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, C, E)
★Union Carbide Plastics Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, C)
★United States Gypsum Co., Chicago 6, Ill. (B)
Valite Div. of Valentine Sugars, Inc., New Orleans, La. (C)
Vanguard Products, Inc., Newark 2, N. J. (D)
Varcum Chemical Corp., Niagara Falls, N. Y. (C)
Whitehouse Reinforced Plastic Co., Fort Worth, Texas (D)
Witte, John H., & Sons, Resin Div., Burlington, Iowa (B, C, D)

LATICES

(See Emulsions and Dispersions)

MOLDING COMPOUNDS

A. *Acrylate and Methacrylate*
B. *Acrylonitrile-Butadiene Styrene*
C. *Acrylonitrile-Styrene*
D. *Alkyd*
E. *Cellulose Acetate*
F. *Cellulose Acetate Butyrate*
G. *Cellulose Propionate*
H. *Chlorinated Polyether*
I. *Cold Molded*
J. *Diallyl Phthalate*
K. *Epoxy*
L. *Ethyl Cellulose*
M. *Fluorocarbons*
N. *Furan*
O. *Melamine*
P. *Nylon*
Q. *Phenolic*
R. *Polyacrylic Ester*
S. *Polycarbonate*
T. *Polyethylene, Low-Density*
U. *Polyethylene, Med.-Density*
V. *Polyethylene, High-Density*
W. *Polyoxymethylene*
X. *Polypropylene*
Reinforced (See p. 1111)
Y. *Shellac*
Z. *Silicone*
AA. *Styrene and Styrene Copolymers*
BB. *Styrene Alloys*
CC. *Urea-Formaldehyde*
DD. *Vinyl Acetal*
EE. *Vinyl Acetate*
FF. *Vinyl Alcohol*
GG. *Vinyl Chloride*
HH. *Vinyl Chloride-Acetate*
II. *Vinylidene Chloride*
JJ. *Vinyl Formal*

A.A.A. Plastic Co., New York 17, N. Y. (DD, EE, FF, GG, HH)
Acco Polymers, Brooklyn 22, N. Y. (A, R)
★Acme Resin Corp., Forest Park, Ill. (J)
Adhesive Products Corp., New York 60, N. Y. (X)
Aerojet-General Corp., Structural Plastics Div., Azusa, Calif. (K, Q)
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., New York 17, N. Y. (FF)
Alladin Plastics, Inc., Gardena, Calif. (C, U, V, AA)
Allied Chemical Corp., General Chemical Div., New York 6, N. Y. (M)
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (P)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (D, J, M, O, P, Q, T, U, V, CC)
★Allied Chemical Corp., Semet-Solvay Div., New York 6, N. Y. (T, V)
Alpha Chemical & Plastics Corp., Newark 5, N. J. (E, T, U, V, GG)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (O, CC)
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (B)
American-Marietta Co., Adhesive, Resin & Chemical Div., Seattle 5, Wash. (K)
American-Marietta Co., Booty Resineers Div., Newark, Ohio (K)
★American Molding Powder & Chemical Corp., Brooklyn 6, N. Y. (T, U, V)
American Reinforced Plastics Co., Los Angeles 27, Calif. (Q)
American Viscose Corp., Philadelphia 3, Pa. (CC)
Aries Laboratories, Inc., Long Island City, N. Y. (K)
★Auburn Plastics, Inc., Auburn, N. Y. (GG)
B. X. Plastics, Ltd., London, Eng. (E, P, AA, BB)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (B, C, P, T, U, V, AA, GG, II)
Baker, J. T., Chemical Co., Phillipsburg, N. J. (A)
Bamberger, Claude P., Inc., Ridgefield Park, N. J. (E, AA)
Biggs, Carl H., Co., Inc., Santa Monica, Calif. (K)
★Blane Corp., The, Canton, Mass. (T, U, V, GG)
Blum, Paul, Co., Buffalo 10, N. Y. (A, E, F, L, T, V, AA, GG)
Borden Chemical Co., The, New York 17, N. Y. (EE, GG, HH)
Brilhart Plastics Corp., Mineola, N. Y. (I, K, AA)
British Geon, Ltd., London W. 1, England (GG, HH)
British Resin Products, Ltd., London W. 1, England (Q, V, AA)
Calresin Co., Div. of Knudsen Creamery, Los Angeles 39, Calif. (J, K, O, Q)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (GG, HH)
★Cary Chemicals, Inc., New Brunswick, N. J. (GG)
★Cassella Farbwerke Mainkur, A. G., Frankfurt/Main, West Germany (O)
★Catalin Corp. of America, New York 16, N. Y. (C, P, T, U, V, AA, BB)
Celanese Corp. of America, Chemical Div., New York 16, N. Y. (E, G, V)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (E, G, V)
★Chemical Products Corp., E. Providence 14, R. I. (GG)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (C, V, X, AA, GG, HH)
★Chemore Corp., New York, N. Y. (X, CC, GG, HH)

★ Indicates Advertiser

Chemtron Fiber Glass Co., El Monte, Calif. (K)
★Clinton Co., The, Chicago 22, Ill. (K)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Cleveland 14, Ohio (EE)
Connecticut Hard Rubber Co., New Haven 10, Conn. (Z)
★Cooke Color & Chemical Co., Hackettstown, N. J. (T, U, V)
Cordo Chemical Corp., Norwalk, Conn. (K)
★Cosden Petroleum Corp., Big Spring, Texas (AA)
★Davies Nitrate Co., Inc., New York 6, N. Y. (M)
★Davis, Joseph, Plastics Co., Kearny, N. J. (E, L)
★Dayton Rubber Co., The, Dayton, Ohio (D)
Dennis Chemical Co., St. Louis 3, Mo. (K, GG, HH, II)
★Diamond Alkali Co., Cleveland 14, Ohio (GG, HH)
★Dow Chemical Co., The, Midland, Mich. (C, L, T, U, AA, BB, GG, II)
Dow Corning Corp., Midland, Mich. (Z)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, E, M, P, T, V, W)
★Durez Plastics Div., Hooker Chemical Corp., N. Tonawanda, N. Y. (J, Q)
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (E, L, O, Q, AA, CC, GG, HH)
Eastern Plastic Materials, Slatersville, R. I. (E, L, T, U, V, X, AA)
★Eastman Chemical Products, Inc., Plastics Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (E, F, G, T, U, X)
Ellay Rubber Co., Los Angeles 24, Calif. (GG)
Emerson & Cuming, Inc., Canton, Mass. (K)
Erie Plastics Co., Erie, Pa. (A, B, C, E, F, P, T, U, V, X, AA, DD, EE, FF, GG, HH)
Erinoid, Ltd., London, England (B, C, E, T, U, V, AA, GG)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (B, E, F, P, S, Z)
★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (M, V, X, DD, EE, FF, GG, HH)
★Fiberfil, Inc,, Warsaw, Ind. (C, P, AA)
★Fiberite Corp., The, Winona, Minn. (K, O, Q)
Firestone Plastics Co., Pottstown, Pa. (P, GG, HH)
Flexcraft Industries, Newark, N. J. (E)
Flexible Products Co., Marietta, Ga. (GG, HH)
★Foster Grant Co., Inc., Leominster, Mass. (C, P, AA, BB)
★Furane Plastics, Inc., Los Angeles 39, Calif. (J, K, N)
★Garfield Mfg. Co., Wallington, N. J. (I, K, O, Q)
★General Electric Co., Chemical Materials Dept., Pittsfield, Mass. (Q, S)
★General Tire & Rubber Co., The, Chemical Div., Akron 9, Ohio (GG)
★Gering Products, Inc., Kenilworth, N. J. (A, C, E, F, G, L, P, T, U, V, X, AA, BB, GG, HH)
Gisholt Machine Co., Madison 4, Wis. (K, O)
Glaskyd, Inc., Perrysburg, Ohio (D)
Gordon Chemicals, Inc., Wilmington, Del. (CC)
★Great American Plastics Co., Fitchburg, Mass. (GG)
Hastings Plastics, Inc., Santa Monica, Calif. (K, Q)
★Hercules Powder Co., Inc., Wilmington 99, Del. (H, V, X)
Heresite & Chemical Co., Manitowoc, Wis. (Q)
Hewitt, C. B., & Bros., Inc., New York 13, N. Y. (CC, FF)
Holman Mfg. Co. Inc., Hoosick Falls, N. Y. (A, C, D, E, F, J, K, O, P, Q, S, AA, CC)
Houghton Laboratories, Inc., Olean, N. Y. (K, GG)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (A, M, P, T, X, AA, CC, GG)
Industrial Sales Engineers, New York 17, N. Y. (DD, EE, FF, GG, HH)
International Textile Co., Chicago 39, Ill. (O, Q)
★Interplastics Corp., New York 22, N. Y. (A, C, E, F, L, P, T, U, V, X, AA, GG)
Isochem Resins Corp., Providence 9, R. I. (K)
Kish Industries, Inc., Lansing 6, Mich. (K)
Kleestron Ltd., London, England (T, V, AA)
★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (T, U, V, AA, BB)
Lakeside Plastics Corp., Oshkosh, Wis. (D, K, GG)
Lavorazione Materie Plastiche, S.A.S., Torino, Italy (GG)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (K)
Lebec Chemical Corp., Paramount, Calif. (Q)
Macromol Corp., The, Matawan, N. J. (B, C, AA, BB)
Magnolia Plastics, Inc., Chamblee, Ga. (A, K, Q)
★Marbon Chemical Div., Borg-Warner Corp., Washington, W, Va. (B)
Maynard Plastics, Inc., Salem, Mass. (T, U, V, X, AA, GG, II)
Mazzucchelli Celluloide S.p.A., Castiglione Olona (Varese), Italy (E, AA)
Melamine Plastics, Inc., Winona, Minn. (O)
Mesa Plastics Co., Los Angeles 25, Calif. (J, K, Z)
Minnesota Mining & Mfg. Co., Chemical Div., St. Paul 6, Minn. (M)
★Monsanto Chemical Co., Plastics Div., Springfield, Mass. (T, U, AA, BB, GG)
★Muehlstein, H., & Co., N. Y., N. Y. (A, E, F, P, T, U, V, AA, GG, HH)
Munray Products Div., The Fanner Mfg. Co., Cleveland, Ohio (GG, HH)
★National Polymer Products, Inc., Reading, Pa. (P)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (B, C, GG, HH)
New England Tape Co., Hudson, Mass. (GG)
★Omni Products Corp., New York 16, N. Y. (Q, T, U, V)
O'Sullivan Rubber Corp., Winchester, Va. (GG, HH)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (GG)
Peerless Chemical Corp., Verplanck, N. Y. (E)
Pelmor Laboratories, Inc., Newtown, Pa. (B, C, F, Z)
Pennsylvania Industrial Chemical Corp., Clairton, Pa. (I)
★Phillips Chemical Co., Bartlesville, Okla. (V)
Plastex Laminates, Inc., Hialeah, Fla. (A, K, Z, AA)
Plastic Materials, Inc., Hicksville, L. I., N. Y. (E, L, T, U, V, X, AA)
★Plastic Molders Supply Co., Inc., Fanwood, N. J. (T, U, V)
Plastic Molding Powders, Inc., Brooklyn 23, N. Y. (A, E, F, T, U, V, AA, GG)
★Plastics Engineering Co., Sheboygan, Wis. (Q)
Poly-Cell Plastics Co., Smithtown, N. Y. (E)
Polymer Chemical Co., Cincinnati 12, Ohio (GG)
★Polypenco, Inc., Reading, Pa. (P)
Premier Thermo Plastics Co., Jeffersontown, Ky. (GG, HH)
Quelcor, Inc., Chester, Pa. (GG)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (K, Q, Z)
★Reed Plastics Corp., Worcester 8, Mass. (A, B, C, E, F, G, P, T, U, V, X, AA, BB, EE, GG, HH)
★Reichhold Chemicals, Inc., White Plains, N. Y. (K, Q)
Ren Plastics, Inc., Lansing 9, Mich. (K)
★Reynolds Chemical Products Co., Whitmore Lake, Mich. (GG, HH, II)
Rogers Corp., Rogers, Conn. (J, M, Q)
★Rohm & Haas Co., Philadelphia 5, Pa. (A)
★Rubber Corp. of America, Hicksville, N. Y. (GG, HH)
Salem Plastic Chemicals, Inc., Chelsea, Mass. (G, T, U, V, GG, HH)
Sartomer Resins, Inc., Philadelphia 4, Pa. (A, C, R)
Schramm Fiberglass Products, Inc., Chicago 18, Ill. (K)
Seamco Chemical Co., Holyoke, Mass. (AA)
Shawinigan Resins Corp., Springfield 1, Mass. (DD, EE, FF, JJ)
Smooth-On Mfg. Co., Jersey City 4, N. J. (K)
Solvic S.A., Brussels 4, Belgium (GG)
★Spencer Chemical Co., Kansas City 5, Mo. (P, T, U, X)
Supplex Co., Div. of Amerace Corp., Garwood, N. J. (T, U, V, GG, HH)
Styrene Products Ltd., London W. 1, England (C, AA)
Sylvan Plastics, Inc., Philadelphia 3, Pa. (CC)
Synthetic Plastics, Newark, N. J. (CC)
Synvan Corp., Wilmington 99, Del. (Q)
Technicraft Co., Boston 34, Mass. (T)
★U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., New York 16, N. Y. (U)
★U. S. Polymeric Chemicals, Inc., Stamford, Conn. (J, K, Q, Z)
Union Carbide Corp., Silicones Div., New York 17, N. Y. (Z)
★Union Carbide International Co., Div. of Union Carbide Corp., N. Y., N. Y. (B, C, Q, T, U, V, Z, AA, GG, HH)
★Union Carbide Plastics Co., Div. of of Union Carbide Corp., N. Y., N. Y. (C, Q, T, U, V, AA, GG, HH)
Valite Div. of Valentine Sugars, Inc., New Orleans, La. (Q)
Varcum Chemical Corp., Niagara Falls, N. Y. (Q)
Vereinigte Chemische Fabriken, Vienna, Austria (O, Q, CC)
Witte, John H., & Sons, Resin Div., Burlington, Iowa (D, K, Q)
★Woloch, George, Co., Inc., New York 11, N. Y. (C, P, T, U, V, GG, HH)
Worbla, Ltd., Papiermuhle-Bern, Switzerland (C, E, L, Q, T, U, AA, GG, HH)
Yates Co., Erie, Pa. (GG)

ORGANOSOLS AND PLASTISOLS

A. Nylon-Based
B. Vinyl-Based Organosols
C. Vinyl-Based Plastisols

A.A.A. Plastic Co., N. Y., N. Y. (B, C)
★Acheson Dispersed Pigments Co., Unit of Acheson Industries, Philadelphia 3, Pa. (B, C)

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Adhesive Products Corp., New York 60, N. Y. (A, B, C)
American Latex Products Corp., Hawthorne, Calif. (B, C)
Armitage, John L., Co., Newark, N. J. (B, C)
Atlas Coatings Corp., Long Island City 1, N. Y. (B, C)
★Auburn Plastics, Inc., Auburn, N. Y. (B, C)
Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (A, B, C)
★Bee Chemical Co., Chicago 33, Ill. (B, C)
★Blane Corp., The, Canton, Mass. (C)
Borden Chemical Co., The, New York 17, N. Y. (B, C)
Bostrom Corp., Milwaukee 4, Wis. (B, C)
Bradley & Vrooman Co., Chicago 16, Ill. (B, C)
Calresin Co., Div. of Knudsen Creamery, Los Angeles 39, Calif. (B, C)
Carroll Products, Inc., Farmingdale, N. Y. (B)
Chemical & Engineering Associates, Upper Darby, Pa. (B, C)
★Chemical Products Corp., E. Providence 14, R. I. (B, C)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (C)
★Clinton Co., The, Chicago 22, Ill. (B, C)
Cordo Chemical Corp., Norwalk, Conn. (B, C)
Dennis Chemical Co., St. Louis 3, Mo. (B, C)
Dewey & Almy Chemical Co., Div., W. R. Grace & Co., Cambridge 40, Mass. (B, C)
Electro-Technical Products Div., Sun Chemical Corp., Nutley 10, N. J. (B)
Emerson & Cuming, Inc., Canton, Mass. (C)
Flexcraft Industries, Newark, N. J. (B, C)
Flexible Products Co., Marietta, Ga. (B, C)
★Furane Plastics, Inc., Los Angeles 39, Calif. (C)
Geneve Mfg. Corp., Trenton, N. J. (C)
★Glidden Co., The, Cleveland 14, Ohio (B, C)
Goodrich, B. F., Industrial Products Co., Akron 18, Ohio (B, C)
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y. (B, C)
Hastings Plastics, Inc., Santa Monica, Calif. (C)
Holman Mfg. Co., Inc., Hoosick Falls, N. Y. (A)
Houghton Laboratories, Inc., Olean, N. Y. (C)
Industrial Sales Engineers, N. Y. 17, N. Y. (B, C)
Interchemical Corp., Finishes Div., Newark 5, N. J. (B, C)
Isochem Resins Corp., Providence 9, R. I. (C)
Jamestown Finishes, Inc., Jamestown, N. Y. (B, C)
L & P Tool Co., Cincinnati 25, Ohio (C)
Lakeside Plastics Corp., Oshkosh, Wis. (B, C)
Landers Corp., The, Toledo 1, Ohio (B, C)
★Lawter Chemicals, Inc., Chicago 45, Ill. (C)
★Logo Div., Bee Chemical Co., Chicago 33, Ill. (B, C)
Marbek, Inc., Brooklyn 22, N. Y. (C)
Maynard Plastics, Inc., Salem, Mass. (B, C)
★Metal & Thermit Corp., Rahway, N. J. (B, C)
★Michigan Chrome & Chemical Co., Detroit 13, Mich. (B, C)
Midland Adhesive & Chemical Corp., Ferndale 20, Mich. (B, C)
Morningstar-Paisley, Inc., New York 19, N. Y. (B, C)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (B, C)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (B, C)
New England Tape Co., Hudson, Mass. (B, C)
★Omni Products Corp., New York 16, N. Y. (C)
Parcloid Chemical Co., Midland Park, N. J. (B, C)
Pasley's Plastc Products, Inc., Atlanta 18, Ga. (B, C)
Polykote, Inc., Cleveland 3, Ohio (B, C)
Polymer Chemical Co., Cincinnati 12, Ohio (C)
Poly Resins, Sun Valley, Calif. (B, C)
Protective Treatment's, Inc., Dayton 3, Ohio (B, C)
Pyroxylin Products, Inc., Chicago 32, Ill. (B, C)
Quelcor, Inc., Chester, Pa. (C)
★Reed Plastics Corp., Worcester 8, Mass. (B, C)
Research Sales, Inc., Suffern, N. Y. (C)
★Reynolds Chemical Products Co., Whitmore Lake, Mich. (B, C)
★Rubber Corp. of America, Hicksville, N. Y. (B, C)
★Stanley Chemical Co., The, East Berlin, Conn. (B, C)
★Sullivan Varnish Co., Chicago 22, Ill. (B, C)
Sun Steel Co., Chicago 36, Ill. (C)
Technicraft Co., Boston 34, Mass. (C)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, C)
★Union Carbide Plastics Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, C)
★Watson-Standard Co., Pittsburgh 12, Pa. (A, B, C)
Western Coating Co., Royal Oak, Mich. (B, C)

PHOTOELASTIC PLASTICS

Applied Plastics., Inc., El Segundo, Calif.
Brilhart Plastics Corp., Mineola, N. Y.
★Catalin Corp. of America, New York 16, N. Y.
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany
Houghton Laboratories, Inc., Olean, N. Y.

RADIOACTIVE ISOTOPES

Radiation Applications, Inc., New York 17, N. Y.
United States Radium Corp., Morristown, N. J.

RESIN-FABRIC BOARDS AND BLANKS

(For Molding or Laminating)

Cordo Chemical Corp., Norwalk, Conn.
Polyplastex United, Inc., Union, N. J.
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa.
Rogers Corp., Rogers, Conn.
★Standard Insulation Co., Inc., E. Rutherford, N. J.

RESIN SOLUTIONS

(See Coatings, Emulsions, Latices, Varnishes)

RESINS

A. Acrylic (Including Copolymers)
B. Alkyd
C. Allyl
D. Aniline-Formaldehyde
E. Cast Phenolic
F. Coumarone-Indene
G. Epoxy
H. Fluorocarbons
I. Furan
J. Hydrocarbon (Petroleum)
K. Hydrocarbon (Terpene)
L. Ion Exchange
M. Isocyanates
N. Lignin Derivatives
O. Melamine
P. Nylon (Polyamide)
Q. Oil Soluble
R. Phenolic
S. Polycarbonate
T. Polyester
U. Polyethylene
V. Polyoxymethylene
W. Polypropylene
X. Resorcinol-Aldehyde
Y. Rosin
Z. Silicone
AA. Sodium Carboxymethyl
BB. Styrene (Including Derivatives and Copolymers)
CC. Urea-Formaldehyde
DD. Varnish and Lacquer Making
EE. Vinyl Acetate
FF. Vinyl Alcohol
GG. Vinyl Butyral
HH. Vinyl Chloride
II. Vinyl Chloride-Acetate
JJ. Vinyl Chloride-Vinylidene Chloride
KK. Vinyl Formal
LL. Vinylidene Chloride (Saran)
MM. Water Soluble

Acco Polymers, Brooklyn 22, N. Y. (A)
★Acme Resin Corp., Forest Park, Ill. (C, R, MM)
Aerojet-General Corp., Structural Plastics Div., Azusa, Calif. (G, R)
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., New York 17, N. Y. (FF)
Alcylite Plastics & Chemical Corp., Newhall, Calif. (D, E, I, O, Q, R, X, CC, MM)
Alkydol Laboratories, Inc., Cicero 50, Ill. (A, B, G, Q, T, Y, DD, MM)
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (M)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (B, F, M, O, P, Q, R, T, U, Z, BB, CC, DD, MM)
★Allied Chemical Corp., Semet-Solvay Div. New York 6, N. Y. (U)
American Alkyd Industries, Carlstadt, N. J. (B, Q, T, CC, DD)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (B, O, T, BB, CC, MM)
American Latex Products Corp., Hawthorne, Calif. (M, T)
American-Marietta Co., Adhesive, Resin & Chemical Div., Seattle 5, Wash. (O, R, X, CC)
American-Marietta Co., Booty Resineers Div., Newark, Ohio (B, O, R, X, CC)

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American Reinforced Plastics Co., Los Angeles 27, Calif. (R)

American Resin Corp., Chicago 13, Ill. (G, R, T)

Amoco Chemicals Corp., Chicago 80, Ill. (K)

Applied Plastics., Inc., El Segundo, Calif. (G, M, R)

Archer-Daniels-Midland Co., Minneapolis, Minn. (B, G, Q, R, Y, DD, MM)

Aries Laboratories, Inc., Long Island City, N. Y. (G, DD)

Armstrong Products Co., Warsaw, Ind. (G)

Atlas Powder Co., Wilmington, Del. (T)

AviSun Corp., Philadelphia 3, Pa. (W)

B. X. Plastics, Ltd., London, England (BB)

★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (A, G, P, R, T, U, BB, CC, DD, HH, II, LL, MM)

Baker J. T., Chemical Co., Phillipsburg, N. J. (A)

★Belding Corticelli Industries, New York 18, N. Y. (P)

Borden Chemical Co., The, New York 17, N. Y. (A, G, R, X, CC, EE, FF, HH, II, MM)

Brilhart Plastics Corp., Mineola, N. Y. (G, M, T)

British Geon, Ltd., London W. 1, England (HH, II, JJ)

British Resin Products, Ltd., London W. 1, England (B, F, O, Q, R, T, U, X, CC, DD, EE, MM)

Calresin Co., Div. of Knudsen Creamery, Los Angeles 39, Calif. (G, O, R, T, BB, CC, DD, HH, II, LL)

Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (HH, II)

Carwin Co., The, North Haven, Conn. (M)

★Cary Chemicals, Inc., New Brunswick, N. J. (HH, II)

★Cassella Farbwerke Mainkur, A. G., Frankfurt/Main, West Germany (O, DD, MM)

★Catalin Corp. of America, New York 16, N. Y. (A, O, R, X, CC, MM)

Celanese Corp. of America, Chemical Div., New York 16, N. Y. (T, U, EE)

★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (T, U, EE)

Chase Chemical Corp., Pittsburgh 1, Pa. (M)

Chemical Coating & Engineering Co., Inc., Media, Pa. (G, M)

★Chemical Development Corp., Danvers, Mass. (A, G)

★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (T, U, W, BB, DD, HH, II)

★Chemore Corp., New York, N. Y. (W, CC, HH, II)

★Ciba Products Corp., Fair Lawn, N. J. (G)

Colton Chemical Co., Div. of Air Reduction Co., Inc., Cleveland 14, Ohio (EE, FF)

Connecticut Hard Rubber Co., New Haven 10, Conn. (Z)

Crownoil Chemical Co., Long Island City 1, N. Y. (B)

★Davies Nitrate Co., Inc., New York 6, N. Y. (H)

★Dayton Rubber Co., The, Dayton, Ohio (B, M, T)

Dennis Chemical Co., St. Louis 3, Mo. (EE, HH, II, JJ, LL)

★Devcon Corp., Danvers, Mass. (G)

★Diamond Alkali Co., Cleveland 14, Ohio (HH, II)

★Dow Chemical Co., The, Midland, Mich. (A, G, BB, HH, JJ, LL)

Dow Corning Corporation, Midland, Mich. (Z)

★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, H, M, P, U, V, EE, FF, GG)

★Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y. (I, Q, R, T, DD, MM)

★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köhn, West Germany (E, O, R, CC)

Eastman Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (U, DD)

★Eastman Chemical Products, Inc., Plastics Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (U, W)

Emerson & Cuming, Inc., Canton, Mass. (G, K, M, T, BB)

Epoxylite Corp., El Monte, Calif. (G)

Erie Plastics Co., Erie, Pa. (A, P, U, W, BB, EE, FF, HH, II)

★Escambia Chemical Corp., New York 16, N. Y. (HH)

Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (B, G, L, R, T, Z)

★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (U, W, EE, FF, GG, HH, II, KK)

Firestone Plastics Co., Pottstown, Pa. (H, P, DD, EE, HH, II)

★Food Machinery & Chemical Corp., Chemicals & Plastics Div., New York 17, N. Y. (C)

★Frank, J. P., Chemical Corp., Brooklyn 34, N. Y. (HH, II)

★Freeman Chemical Corp., Port Washington, Wis. (A, B, G, M, Q, T, BB, DD)

★Furane Plastics, Inc., Los Angeles 39, Calif. (G, I, M)

★General Electric Co., Chemical Materials Dept., Pittsfield, Mass. (R, S)

General Electric Co., Silicone Products Dept., Waterford, N. Y. (Z)

★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn. (G)

General Mills, Inc., Kankakee, Ill. (P)

★General Tire & Rubber Co., The, Chemical Div., Akron 9, Ohio (HH)

Gisholt Machine Co., Madison, Wis. (G)

Glasflex, Inc., Stirling, N. J. (A)

★Glidden Co., The, Cleveland 14, Ohio (A, B, J, K, M, O, Q, R, T, Y)

★Goodrich, B. F., Chemical Co., Cleveland 15, Ohio (HH, II, JJ, MM)

★Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio (T, BB, HH)

Gore, W. L., & Assoc., Newark, Del. (H)

★Grace, W. R., & Co., Polymer Chemicals Div., Clifton, N. J. (U)

★Great American Plastics Co., Fitchburg, Mass. (HH)

★Harwick Standard Chemical Co., Akron 5, Ohio (F, J, K, Q, Y, Z)

Hastings Plastics, Inc., Santa Monica, Calif. (G, T)

★Hercules Powder Co., Inc., Wilmington 99, Del. (B, U, W, Y, CC, DD)

Heresite & Chemical Co., Manitowoc, Wis. (R)

Hewitt, C. B., & Bros., Inc., New York 13, N. Y. (CC, EE, FF)

Houghton Laboratories, Inc., Olean, N. Y. (G)

★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (A, B, M, P, Q, R, T, CC, DD, EE, II)

Industrial Plastic Coating Corp., Clifton, N. J. (H)

Interchemical Corp., Finishes Div., Newark 5, N. J. (T)

Isochem Resins Corp., Providence 9, R. I. (G, M, T)

Joclin Mfg. Co., Wallingford, Conn. (H)

★Jones-Dabney Co., Louisville 8, Ky. (B, G, CC, EE)

Kenrich Corp., Maspeth 78, N. Y. (K)

Knoedler Chemical Co., Lancaster, Pa. (E)

Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa. (X, BB, MM)

★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (U, BB)

Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa. (R)

★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (U, BB, DD)

Krumbhaar Chemicals, Inc., So. Kearny, N. J. (B, Q, R, DD)

Lakeside Plastics Corp., Oshkosh, Wis. (B, G, Q, T, DD, GG, HH)

Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (G)

★Lawter Chemicals, Inc., Chicago 45, Ill. (B, Q, R, DD)

Lebec Chemical Corp., Paramount, Calif. (A, E, R, CC, MM)

Macromol Corp., Matawan, N. J. (BB)

★Marblette Corp., The, Long Island City 1, N. Y. (E, G, R)

★Marbon Chemical Div., Borg-Warner Corp., Washington, W. Va. (BB)

Maynard Plastics, Inc., Salem, Mass. (U, HH)

McCloskey Varnish Co., Philadelphia 36, Pa. (B, G, R, DD)

Mesa Plastics Co., Los Angeles 25, Calif. (C)

Minnesota Mining & Mfg. Co., Chemical Div., St. Paul 6, Minn. (H, Q, R)

Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn. (DD)

Mitchell Rand Mfg. Corp., New York 7, N. Y. (G)

Mobay Chemical Co., Pittsburgh 34, Pa. (M, T)

Mol Rez Div., American Petrochemical Corp., Minneapolis, Minn. (B, M, T)

★Monsanto Chemical Co., Plastics Div., Springfield 2, Mass. (O, R, U, BB, HH, II)

★Muehlstein, H., & Co., New York 17, N. Y. (A, P, U, BB, HH, II)

National Aluminate Corp., Chicago 38, Ill. (L)

★National Polychemicals, Inc., Wilmington, Mass. (N, O, Q, R, X, CC, EE, MM)

★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (B, M, T, HH, II)

Newport Industries Co., A Div. of Heyden Newport Chemical Corp., New York 17, N. Y. (Y)

★Nopco Chemical Co., N. Arlington, N. J. (M, T)

★Omni Products Corp., New York 16, N. Y. (R, T, BB)

Onyx Oil & Chemical Co., Jersey City 2, N. J. (A, Z, CC)

Osborn, C. J., Co., Linden, N. J. (B, G, Q, DD)

Pantasote Co., The, Passaic, N. J. (HH)

Pasley's Plastic Products, Inc., Atlanta 18, Ga. (DD, HH)

Pennsylvania Industrial Chemical Corp., Clairton, Pa. (F, J, K)

Permacel, New Brunswick, N. J. (G, H)

★Phillips Chemical Co., Bartlesville, Okla. (U)

Plastic Laminates, Inc., Hialeah, Fla. (A, G, T, Z, BB, CC)

★Plastic Molders Supply Co., Inc., Fanwood, N. J. (T)

Plastics by Chapman, Richmond, Calif. (A)

★Plastics Engineering Co., Sheboygan, Wis. (R)

★Polypenco, Inc., Reading, Pa. (H, P, S, BB)

Poly Resins, Sun Valley, Calif. (G, R)

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Polyrez Co., Inc., Woodbury, N. J. (R, X)

★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (A, G, R, Z)

Red Spot Paint & Varnish Co., Inc., Evansville 8, Ind. (DD)

★Reed Plastics Corp., Worcester 8, Mass. (A, U, W, BB)

★Reichhold Chemicals, Inc., White Plains, N. Y. (A, B, E, G, I, O, Q, R, T, X, Y, CC, DD, EE, MM)

Ren Plastics, Inc., Lansing 9, Mich. (G)

★Rohm & Haas Co., Philadelphia 5, Pa. (A, B, L, O, Q, R, T, X, CC, DD, MM)

★Rubber Corp. of America, Hicksville, N. Y. (HH, II)

Sartomer Resins, Inc., Philadelphia 4, Pa. (A, C, BB)

Schenectady Varnish Co., Schenectady 1, N. Y. (R, DD, EE, GG)

Shanco Plastics & Chemicals, Inc., Tonawanda, N. Y. (Q, R, T, BB)

Shawinigan Resins Corp., Springfield 1, Mass. (EE, FF, GG, KK)

★Shell Chemical Corp., N. Y., N. Y. (G)

Solvic S.A., Brussels 4, Belgium (HH, II)

★Spencer Chemical Co., Kansas City 5, Mo. (P, U, W)

Steelcote Mfg. Co., St. Louis 3, Mo. (DD)

Stein, Hall & Co., Inc., New York 17, N. Y. (EE)

Styrene Products, Ltd., London W. 1, England (L, BB)

★Sullivan Varnish Co., Chicago 22, Ill. (B, Q, DD)

Synco Resins, Inc., Bethel, Conn. (Q, R, DD, EE)

Synvan Corp., Wilmington 99, Del. (R, X, CC)

Thompson Chemical Co., Pawtucket, R. I. (HH)

Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y. (MM)

Union Carbide Corp., Silicones Div., New York 17, N. Y. (Z)

★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (G, H, R, U, Z, BB, GG, HH, II)

★Union Carbide Plastics Co., Div. of Union Carbide Corp., New York 17, N. Y. (G, R, U, BB, DD, EE, FF, GG, HH, II)

★U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., New York 16, N. Y. (U)

★United States Gypsum Co., Chicago 6, Ill. (G)

Valite Div. of Valentine Sugars, Inc., New Orleans, La. (E, R)

Varcum Chemical Corp., Niagara Falls, N. Y. (Q, R, X)

Velsicol Chemical Corp., Chicago 11, Ill. (F, J, BB)

Vereinigte Chemische Fabriken, Vienna, Austria (O, R, CC)

Whitehouse Reinforced Plastic Co., Fort Worth, Texas (T)

★Witco Chemical Co., Inc., New York 17, N. Y. (T)

Witte, John H., & Sons, Resin Div., Burlington, Iowa (B, G, M, R, T, DD)

★Woloch, George, Co., Inc., New York 11, N. Y. (U, BB, HH)

Xylos Rubber Co., Akron 1, Ohio (BB)

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RUBBER, SYNTHETIC

A. Butadiene-Acrylonitrile
B. Butadiene-Styrene (GR-S)
C. Butyl
D. Chloroprene
E. Chlorosulfonated Polyethylene
F. Fluororubbers
G. Hevea
H. Isocyanate
I. Polyacrylic Ester
J. Polyisobutylene
K. Polysulfide
L. Polyurethane
M. Silicone

American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (A, B, C, D, G, J)

American Latex Products Corp., Hawthorne, Calif. (H, L)

Applied Plastics, Inc., El Segundo, Calif. (H)

B. B. Chemical Co., Cambridge 39, Mass. (L)

★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (I, J)

British Geon, Ltd., London W. 1, England (A)

Carwin Co., The, North Haven, Conn. (L)

Chemical Coating & Engineering Co., Inc., Media, Pa. (D, H, L)

★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (B)

Connecticut Hard Rubber Co., New Haven 10, Conn. (M)

★Cooke Color & Chemical Co., Hackettstown, N. J. (C)

★Dayton Rubber Co., The, Dayton, Ohio (A, B, C, G, H, L, M)

Disogrin Industries, Inc., Mt. Vernon, N. Y. (L)

Dow Corning Corp., Midland, Michigan (M)

★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (D, E, F)

Emerson & Cuming, Inc., Canton, Mass. (H, K)

★Enjay Co., Inc., New York 2, N. Y. (C)

Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (A, D, M)

Firestone Plastics Co., Pottstown, Pa. (A, B, G)

General Electric Co., Silicone Products Dept., Waterford, N. Y. (M)

★General Tire & Rubber Co., The, Chemical Div., Akron 9, Ohio (B, L)

★Goodrich, B. F., Chemical Co., Cleveland 15, Ohio (A, I)

Goodrich-Gulf Chemicals, Inc., Cleveland 15, Ohio (B)

★Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio (A, B)

Hastings Plastics, Inc., Santa Monica, Calif. (K)

Heresite & Chemical Co., Manitowoc, Wis. (A)

★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (A, B, H, L)

Minnesota Mining & Mfg Co., Chemical Div., St. Paul 6, Minn. (F)

Mobay Chemical Co., Pittsburgh 34, Pa. (H, L)

★Muehlstein, H., & Co., New York 17, N. Y. (A, B, D, H, J, K, M)

★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (A, B, L)

O'Sullivan Rubber Corp., Winchester, Va. (A, B)

Putnam Chemical Corp., Beacon, N. Y. (J)

★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (C, M)

★Rubber Corp. of America, Hicksville, N. Y. (B)

Sartomer Resins, Inc., Philadelphia 4, Pa. (I)

★Shell Chemical Corp., New York 20, N. Y. (B)

Thiokol Chemical Corp., Trenton 7, N. J. (C, K)

Union Carbide Corp., Silicones Div., New York 17, N. Y. (M)

★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (A, M)

★United Carbon Co., Inc., Charleston 27, W. Va. (B)

Urethane Corp. of America, Medina, N. Y. (H, L)

★Woloch, George, Co., Inc., New York 11, N. Y. (B)

Xylos Rubber Co., Akron 1; Ohio (A)

SHELLAC

★Clinton Co., The, Chicago 22, Ill.

★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.

VARNISHES, INSULATING

Adhesive Products Corp., N. Y., N. Y.

Applied Plastics Co., Inc., El Segundo, Calif.

Aries Laboratories, Inc., Long Island City, N. Y.

Barrett Varnish Co., Cicero 50, Ill.

British Resin Products, Ltd., London W. 1, England

Carwin Co., The, North Haven, Conn.

Dennis Chemical Co., St. Louis 3, Mo.

Dow Corning Corporation, Midland, Michigan

★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.

Epoxylite Corp., El Monte, Calif.

★Furane Plastics, Inc., Los Angeles 39, Calif.

★General Electric Co., Silicone Products Dept., Waterford, N. Y.

★Glidden Co., The, Cleveland 14, Ohio

Heresite & Chemical Co., Manitowoc, Wis.

Houghton Laboratories, Inc., Olean, N. Y.

★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I, England

Interchemical Corp., Finishes Div., Newark 5, N. J.

Lakeside Plastics Corp., Oshkosh, Wis.

★Marblette Corp., The Long Island City 1, N. Y.

Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn.

Monroe Sander Corp., The, Long Island City 1, N. Y.

★National Polychemicals, Inc., Wilmington, Mass.

Research Sales, Inc., Suffern, N. Y.

Schenectady Varnish Co., Schenectady 1, N. Y.

★Union Carbide Corp., Silicones Div., New York 17, N. Y.

Varcum Chemical Corp., Niagara Falls, N. Y.

VARNISHES, LAMINATING

★Acme Resin Corp., Forest Park, Ill.

Adhesive Products Corp., N. Y., N. Y.

★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y.

American-Marietta Co., Booty Resineers Div., Newark, Ohio

British Resin Products, Ltd., London W. 1, England
Dow Corning Corporation, Midland, Mich.
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.
★Durez Plastics Div., Hooker Chemical Corp., North Tonawonda, N. Y.
Flexcraft Industries, Newark, N. J.
★Furane Plastics, Inc., Los Angeles 39, Calif.
★General Electric Co., Chemical Materials Dept., Pittsfield, Mass.
★Glidden Co., The, Cleveland 14, Ohio
Heresite & Chemical Co., Manitowoc, Wis.
Lakeside Plastics Corp., Oshkosh, Wis.
Lebec Chemical Corp., Paramount, Calif.
Leon Chemical Industries, Inc., Warren, Mich.
Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn.
Monroe Sander Corp., The, Long Island City 1, N. Y.
★National Polychemicals, Inc., Wilmington, Mass.
★Plastics Engineering Co., Sheboygan, Wis.
★Reichhold Chemicals, Inc., White Plains, N. Y.
Research Sales, Inc., Suffern, N. Y.
Schenectady Varnish Co., Schenectady 1, N. Y.
Union Carbide Corp., Silicones Div., New York 17, N. Y.
Varcum Chemical Corp., Niagara Falls, N. Y.

Foamed Plastics and Foaming Agents

For list of distributors, see p. 1160

FOAMED PLASTICS
(Expanded, Cellular)

A. Cellulosic
B. Epoxy
C. Phenolic
D. Polyester (Unsaturated)
E. Polyethylene
F. Polyurethane (Polyester)
G. Polyurethane (Polyether)
H. Rubbers
I. Silicone
J. Styrene (Expandable)
K. Styrene (Expanded)
L. Urea
M. Vinyl

Acme Laminating & Plastics Co., Inc., Detroit, Mich. (F, G)
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (F, G)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (C, D, F, L)
American Cellular Products, Inc., New Castle, Del. (F)
American Latex Products Corp., Hawthorne, Calif. (B, F, G)
Applied Plastics Co., Inc., El Segundo, Calif. (G)
Applied Resins Corp., North Caldwell, N. J. (M)
Archer-Daniels-Midland Co., Minneapolis 2, Minn. (F, G)
Aries Laboratories, Inc., Long Island City, N. Y. (B, F, G)
Armstrong Cork Co., Lancaster, Pa. (K)
Atlas Mineral Products Co., Mertztown, Pa. (F)
Atlas Powder Co., Wilmington 99, Del. (G)
Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (B, E, F, G, M)
B. B. Chemical Co., Cambridge 39, Mass. (F, G)
B. X. Plastics Ltd., London, England (J)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (J, L)
Balsa Ecuador Lumber Corp., New York 36, N. Y. (A)
Bloomingdale Rubber Co., Aberdeen, Md. (B, C)
Bolta Products Div., The General Tire & Rubber Co., Lawrence, Mass. (M)
Bostrom Corp., Milwaukee 4, Wis. (F, G)
Brilhart Plastics Corp., Mineola, N. Y. (B, D, F, G)
Burnett, Wm. T., & Co., Inc., Baltimore 30, Md. (F, G)
Brown Co., Boston 14, Mass. (A)
Carolina Industrial Plastics Div., Essex Wire Corp., Mt. Airy, N. C. (F, G, M)
Carwin Co., The, North Haven, Conn. (F, G)
Chase Chemical Corp., Pittsburgh 1, Pa. (F, G)
Chemical Coating & Engineering Co., Inc., Media, Pa. (F, G)
Chemical & Engineering Associates, Upper Darby, Pa. (F, G, M)
★Chemical Products Corp., E. Providence 14, R. I. (M)
★Chemische, Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (H, M)
Chemtron Fiber Glass Co., El Monte, Calif. (B, C, D, F, G)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Cleveland 14, Ohio (L)
Connecticut Hard Rubber Co., New Haven 10, Conn. (I)
Crest Chemical Industries Corp., Brooklyn 31, N. Y. (M)
Curtiss-Wright Corp., New York 20, N. Y. (F, G)
★Dayton Rubber Co., The, Dayton, Ohio (D, E, F, G, I)
Dennis Chemical Co., St. Louis 3, Mo. (B, M)
★Dow Chemical Co., The, Midland, Mich. (E, J, K)
Dow Corning Corporation, Midland, Mich. (I)
Drew, E. F., & Co., Inc., New York 10, N. Y. (D)
★Dumont Corp., San Rafael, Calif. (B, F, I, K)
Dyfoam Corp., New Castle, Pa. (K)
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (C)
★Eastman Chemical Products, Inc., Plastics Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (E)
Emerson & Cuming, Inc., Canton, Mass. (B, C)
Englander Co., The, Inc., Industrial Plastics Div., Baltimore 23, Md. (F, G)
Erinoid, Ltd., London, England (J, K)
Falcon, Inc., Santa Monica, Calif. (K)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (D, F)
Federal Industries, Belleville 9, N. J. (M)
Flexible Products Co., Marietta, Ga. (B, M)
Foam King, Inc., New York 60, N. Y. (M)
★Freeman Chemical Corp., Port Washington, Wis. (F, G)
★Furane Plastics, Inc., Los Angeles 39, Calif. (B)
General Plastics Mfg. Co., Tacoma 2, Wash. (D, F, G)
General Tire & Rubber Co., The, Marion, Ind. (G)
Gilman Brothers Co., The, Gilman, Conn. (J, K)
★Glidden Co., The, Cleveland 14, Ohio (D, F)
★Glo-Brite Foam Plastic Products, Chicago 45, Ill. (F, G, J, K)
★Goodrich, B. F., Industrial Products Co., Akron 18, Ohio (H, M)
Hanley Plastics Co., St. Louis 17, Mo. (F)
Hastings Plastics, Inc., Santa Monica, Calif. (B, C)
★Imperial Chemical Industries (Hyde), Ltd., Sub of Imperial Chemical Industries, Ltd., Cheshire, England (M)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.1, England (D, F, G)
Interchemical Corp., Finishes Div., Newark, N. J. (M)
Isochem Resins Corp., Providence 9, R. I. (B, D)
Isocyanate Products, Inc., New Castle, Del. (F, G)
Joclin Mfg. Co., Wallingford, Conn. (I)
Kimball Mfg. Corp., San Rafael, Calif. (F)
Kish Industries, Inc., Lansing 6, Mich. (C)
★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (J, K)

★ Indicates Advertiser

L & P Tool Co., Cincinnati 25, Ohio (B, F, G, M)
Lami-Plast Products Co., Tampa 3, Fla. (D, F, G)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (B)
Lawrence Packaging Supply Co., Newark 4, N. J. (F, G)
Lebec Chemical Corp., Paramount, Calif. (C)
Lone Star Plastics Co., Inc., Fort Worth, Texas (J)
Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass. (E)
MacDonald Mfg. Co., New Baltimore, Mich. (K)
Magnolia Plastics, Inc., Chamblee, Ga. (B, G)
★Marblette Corp., The, Long Island City 1, N. Y. (C, F)
Metallic Plastics Corp., Long Island City 1, N. Y. (M)
Mitchell Rand Mfg. Corp., New York 7, N. Y. (B)
Mobay Chemical Co., Pittsburgh 34, Pa. (F, G)
Mol Rez Div., American Petrochemical Corp., Minneapolis 18, Minn. (D, F)
★Mono-Sol Corp., Gary, Ind. (M)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (F, G, H, M)
New England Tape Co., Hudson, Mass. (M)
Newport Plastics Corp., Newport, Vt. (J)
★Nopco Chemical Co., N. Arlington, N. J. (F, G)
Paramount Foam Industries, Ridgefield, N. J. (F, G)
Pearson Industries, Long Island City 1, N. Y. (M)
Pelron Corp., Lyons, Ill. (F, G)
★Pittsburgh Plate Glass Co., Paint Div., Pittsburgh 22, Pa. (D)
Plastic Industrial Products, Div. of Carlon Products Corp., Somerville 44, Mass. (E, F, M)
Plastomer Corp., Detroit 4, Mich. (F, G)
Poly Resins, Sun Valley, Calif. (B, F, M)
Polykote, Inc., Cleveland 3, Ohio (M)
★Reichhold Chemicals, Inc., White Plains, N. Y. (F)
★Reynolds Chemical Products Co., Whitmore Lake, Mich. (F, G, M)
Robinson Foams, Ltd., Toronto, Ont. (F, G)
Robinson Moulded Products, Ltd., Toronto, Ont. (M)
★Rubber Corp. of America, Hicksville, N. Y. (M)
Sheller Mfg. Corp., Portland, Ind. (F, G)
★Stanley Chemical Co., The, East Berlin, Conn. (M)
Star Band Co., Inc., Portsmouth, Va. (J, K)
Styrene Products, Ltd., London W.1, England (J, K)
Supplex Co., Div. of Amerace Corp., Garwood, N.J. (M)
Technical Tape Corp., New Rochelle, N. Y. (E)
Thiokol Chemical Corp., Trenton 7, N. J. (F)
Thombert, Inc., Newton, Iowa (F)
Ultra Plastics, Inc., Philadelphia 30, Pa. (F, G)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (C, E, F, G, I)
★Union Carbide Plastics Co., Div. of Union Carbide Corp., New York 17, N. Y. (C, E, M)
★United Cork Cos., Inc., Kearny, N. J.(J)
Urethane Corp. of America, Medina, N. Y. (F, G)
Vanguard Products, Inc., Newark 2, N. J. (D)
Vereinigte Chemische Fabriken, Vienna, Austria (L)
★Witco Chemical Co., Inc., New York 17, N. Y. (F)
Woodall Industries, Inc., Detroit 34, Mich. (G, K)
Worcester Moulded Plastics Co., Worcester 8, Mass. (K)

FOAMING AGENTS

Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Callery Chemical Co., Pittsburgh 37, Pa.
Chase Chemical Corp., Pittsburgh 1, Pa.
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany
★Harwick Standard Chemical Co., Akron 5, Ohio
Hastings Plastics, Inc., Santa Monica, Calif.
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.1., England
Jefferson Chemical Co., Houston 2, Texas
Mobay Chemical Co., Pittsburgh 34, Pa.
National Aluminate Corp., Chicago, Ill.
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn.
★Union Carbide Corp., Silicones Div., New York 17, N. Y.
United Progress, Inc., Albany 5, N. Y.

Chemicals and Additives

For list of distributors, see p. 1160

ANTISTATIC AGENTS

(See Destaticizers)

ANTI-TACK AGENTS

Adhesive Products Corp., New York 60, N. Y.
Alframine Corp., Paterson 4, N. J.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Bios Laboratories, Inc., N. Y. 23, N. Y.
★Geigy Industrial Chemicals, Yonkers, N. Y.
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.1, England
Mallinckrodt Chemical Works, St. Louis 7, Mo.
Merix Chemical Co., Chicago 49, Ill.
Polyplastex United, Inc., Union, N. J.
Swift & Co., Hammond, Ind.

BACTERIOSTATS

Alframine Corp., Paterson 4, N. J.
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany
Bios Laboratories, Inc., New York 23, N. Y.
Commercial Solvents Corp., New York, N. Y.
★Dow Chemical Co., The, Midland, Mich.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany
★Fine Organics, Inc., Lodi, N. J.
★Geigy, J. R., S.A., Basle 16, Switzerland
★Geigy Industrial Chemicals, Yonkers, N. Y.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
★Monsanto Chemical Co., Organic Chemicals Div., St. Louis 66, Mo.
National Aluminate Corp., Chicago 38, Ill.
★Nuodex Products Co., Div. Heyden Newport Chemical Corp., Elizabeth, N. J.

CATALYSTS AND PROMOTERS

A. Peroxides
B. Miscellaneous

★Advance Solvents & Chemical, Div. of Carlisle Chemical Works, Inc., New Brunswick, N. J. (B)
Allied Chemical Corp., General Chemical Div., New York 6, N. Y. (B)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (A)
American Alkyd Industries, Carlstadt, N. J. (A)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (A, B)
Bios Laboratories, Inc., New York 23, N. Y. (A)
Cadet Chemical Corp., Burt 1, N. Y. (A)
Chase Chemical Corp., Pittsburgh 1, Pa. (B)
★Chemical Development Corp., Danvers, Mass. (A, B)
★Ciba Products Corp., Fair Lawn, N. J. (B)
★Devcon Corp., Danvers, Mass. (B)
★Dow Chemical Co., The, Midland, Mich. (B)
★Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y. (B)
Eagle-Picher Co., The, Cincinnati 1, Ohio (A)
Emerson & Cuming, Inc., Canton, Mass. (A, B)
Erickson, Wallace A., & Co., Chicago 10, Ill. (B)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (A)
Ferro Chemical Corp., Div. of Ferro Corp., Bedford, Ohio (B)
★Fine Organics, Inc., Lodi, N. J. (B)
★Furane Plastics, Inc., Los Angeles 39, Calif. (B)

★ Indicates Advertiser

Garan Chemical Corp., Gardena, Calif. (A)
★General Mills, Inc., Kankakee, Ill. (B)
★Harwick Standard Chemical Co., Akron 5, Ohio (A)
Hastings Plastics, Inc., Santa Monica, Calif. (A)
★Hercules Powder Co., Inc., Wilmington 99, Del. (A)
Isochem Resins Corp., Providence 9, R. I. (B)
Jefferson Chemical Co., Houston 2, Texas (B)
★Jones-Dabney Co., Louisville 8, Ky. (B)
Kish Industries, Inc., Lansing 6, Mich. (A, B)
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (A)
Lancaster Chemical Corp., Carlstadt, N. J. (B)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (B)
Lebec Chemical Corp., Paramount, Calif. (B)
★Lucidol Div., Wallace & Tiernan, Inc., Buffalo 5, N . Y. (A)
Magnolia Plastics, Inc., Chamblee, Ga. (B)
McGean Chemical Co., The, Cleveland 15, Ohio (B)
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y. (A, B)
Merck & Co., Inc., Rahway, N. J. (B)
★Metal & Thermit Corp., Rahway, N. J. (B)
National Aluminate Corp., Chicago 38, Ill. (B)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (B)
★Nuodex Products Co., Div. Heyden Newport Chemical Corp., Elizabeth, N. J. (A, B)
Pennsalt Chemicals Corp., Philadelphia 2, Pa. (B)
★Plastic Molders Supply Co., Inc., Fanwood, N. J. (A)
★Roussel Corp., New York 17, N. Y. (B)
Specialty Chemicals, Inc., Austin, Texas (A)
Sumner Chemical Co., Div. of Miles Lab., New York 17, N. Y. (B)
Technicraft Co., Boston 34, Mass. (A, B)
Thalco, Los Angeles 22, Calif. (A)
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y. (B)
U. S. Peroxygen Corp., Richmond, Calif. (A)

CHEMICALS

A. Acids, Mineral
B. Acids and Anhydrides, Monobasic Organic
C. Acids and Anhydrides, Polybasic
D. Alcohols, Aliphatic
E. Aldehydes and Ketones
F. Alkalies (See also Ammonia)
G. Amines
H. Ammonia Catalysts (See above)
I. Ethers, Esters, Alkyl, and Aryl Halides
J. Fatty Acid Derivatives (Including Stearates)
K. Hydrocarbons, Aliphatic
L. Hydrocarbons, Aromatic
M. Isocyanates
N. Phenols (Aromatic Alcohols)
O. Urea

★Advance Solvents & Chemical, Div. of Carlisle Chemical Works, Inc., New Brunswick, N.J. (J)
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., New York 17, N. Y. (D)
Allied Chemical Corp., General Chemical Div., New York 6, N. Y. (A)
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (C, D, E, G, M)
Allied Chemical Corp., Nitrogen Div., New York 6, N. Y. (D, E, F, G, H, O)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (A, B, C, F, G, H, L, M, N, O)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (C)
American Resin Corp., Chicago 13, Ill. (A, G)
Amoco Chemicals Corp., Chicago 80, Ill. (C, D, L)
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y. (I, N)
Archer-Daniels-Midland Co., Minneapolis 2, Minn. (B, D, G, J, K)
Aries Laboratories, Inc., Long Island City, N. Y. (C, G)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (A, B, C, D, E, F, G, H, I, J, O)
Baker, J. T., Chemical Co., Phillipsburg, N. J. (A)
Bios Labs., Inc., New York 23, N. Y. (A, B, C, D, E, F, G, H, I, J, K, L)
Carwin Co., The, North Haven, Conn. (G, M)
★Celanese Corp. of America, Chemical Div., New York 16, N. Y. (E)
Chemical Coating & Engineering Co., Inc., Media, Pa. (M)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (B, C, D, E, G, I, J, K, L)
Clinton Corn Processing Co., Clinton, Iowa (B)
Commercial Solvents Corp., New York, N. Y. (D, E, G, H, J, K)
Darling & Co., Chicago, Illinois (B, J)
★Davies Nitrate Co., Inc., New York 6, N. Y. (F, M, O)
★Deecy Products Company, Cambridge 42, Mass. (I, J)
★Diamond Alkali Co., Cleveland 14, Ohio (A, C, E, F, I, N)
★Dow Chemical Co., The, Midland, Mich. (A, B, F, G, I, K, L, N)
Drew, E. F., & Co., Inc., New York 10, N. Y. (I)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, B, C, D, E, F, G, H, I, J, L, M, O)
★Eastman Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (B, D, E, G, I)
★Emery Industries, Inc., Cincinnati 2, Ohio (B, C, J)
★Enjay Co., Inc., New York 2, N. Y. (D, E, I)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (B, C, G, I, M)
★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (A, D, I, K)
Fiber Chemical Corp., Cliffwood, N. J. (A)
★Food Machinery & Chemical Corp., Chemicals & Plastics Div. New York 17, N. Y. (I)
Foremost Food & Chemical Co., El Dorado Div., Oakland, Calif. (B, I, J)
★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn. (J)
Gulf Oil Corp., Petrochemicals Dept., Pittsburgh 30, Pa. (K, L)
★Harchem Div., Wallace & Tiernan, Inc., Belleville 9, N. J. (J)
★Harshaw Chemical Co., The, Cleveland 6, Ohio (J)
★Harwick Standard Chemical Co., Akron 5, Ohio (G, J, K, L)
Hastings Plastics, Inc., Santa Monica, Calif. (B, C, E, G, H, L)
★Hercules Powder Co., Inc., Wilmington 99, Del. (B, D, E, G, J, N)
★Hooker Chemical Corp., Niagara Falls, N. Y. (A, C, N)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.1., England (A, D, E, F, G, H, I, K, L, M, N)
Isochem Resins Corp., Providence 9, R. I. (G)
Jefferson Chemical Co., Houston 2, Texas (D, F)
Kay-Fries Chemicals, Inc., New York 16, N. Y. (B, C, E, I)
Kenrich Corp., Maspeth 78, N. Y. (L)
Kessler Chemical Co., Inc., Philadelphia 35, Pa. (I, J)
Kolker Chemical Corp., Newark 5, N. J. (I, J)
Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa. (J, L)
Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa. (B, L, N)
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (A, B, C, D, E, G, I, J, K, L)
Mallinckrodt Chemical Works, St. Louis 7, Mo. (J)
McGean Chemical Co., The, Cleveland 15, Ohio (J)
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y. (A, B, D, E, F, G, H, I, J, L, O)
Minnesota Mining & Mfg Co., Chemical Div., St. Paul 6, Minn. (A)
Mobay Chemical Co., Pittsburgh 34, Pa. (M)
★Monsanto Chemical Co., Organic Chemicals Div., St. Louis 66, Mo. (A, B, C, F, G, H, N)
Morton-Withers Chemical Co. Div., Chas. Pfizer, Greensboro, N. C. (J)
National Aluminate Corp., Chicago 38, Ill. (G, J)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (M)
★Nopco Chemical Co., N. Arlington, N. J. (J)
Olin Mathieson Chemical Corp., Chemicals Div., Baltimore 3, Md. (A, F, H, O)
Onyx Oil & Chemical Co., Jersey City 2, N. J. (G, J)
Optics Mfg. Corp., Phila. 34, Pa. (A)
Oronite Chemical Co., San Francisco 20, Calif. (C)
Pennsalt Chemicals Corp., Philadelphia 2, Pa. (A, D, F, G, H, I, K)
Pennsylvania Industrial Chemical Corp., Clairton, Pa. (K, L)
Petro-Tex Chemical Corp., Houston 1, Texas (K)
Philadelphia Quartz Co., Philadelphia 6, Pa. (F)
Pitt-Consol Chemical Co., Newark 5, N. J. (N)
Quaker Oats Co., The, Chemicals Div., Chicago 54, Ill. (D, E)
★Reichhold Chemicals, Inc., White Plains, N. Y. (A, C, E, J, N)
★Rohm & Haas Co., Philadelphia 5, Pa. (B, D, G)
★Roussel Corp., New York 17, N. Y. (G)
★Rubber Corp. of America, Hicksville, N. Y. (I, J)
★Shell Chemical Corp., New York 20, N. Y. (E, O)

★ **Indicates Advertiser**

Sinclair Petrochemicals, Inc., New York 20, N. Y. (K, L)
Slomons Laboratories, Inc., Long Island City 1, N. Y. (I)
Sumner Chemical Co., Div. of Miles Lab., New York 17, N. Y. (G, J)
Sun Oil Co., Philadelphia 3, Pa. (H, K, L)
Swift & Co., Hammond, Ind. (J)
★Synthetic Products Co., Cleveland 12, Ohio (J)
Tennessee Corp., Atlanta 9, Ga. (A)
Tennessee Products & Chemical Corp., Nashville, Tenn. (A, B, D, E, I, L)
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, C, D, E, G, I, K, L, N)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, C, D, E, G, I, K, N)
★Union Carbide Olefins Co., Div. of Union Carbide Corp., New York 17, N. Y. (L)
★U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., New York 16, N. Y. (A, C, D, E, F, H, I, K)
Velsicol Chemical Corp., Chicago 11, Ill. (L)
Verona Dyestuffs Div. of Verona-Pharma Chemical, Union, N. J. (I)
Victor Chemical Works, Chicago 6, Ill. (A, B, C)
★Whittaker, Clark & Daniels, Inc., New York 7, N. Y. (J)
★Witco Chemical Co., Inc., New York 17, N. Y. (I, J)
Wyandotte Chemicals Corp., Wyandotte, Mich. (F, G, I)

COLORS AND COLORANTS

A. Color Dispersions in Resins and Plasticizers
B. Dyes
C. Hot-Stamping Media
D. Inks
E. Paints
F. Pearl Essences
G. Pigments, Inorganic
H. Pigments, Luminescent
I. Pigments, Metallic
J. Pigments, Organic

★Acheson Dispersed Pigments Co., Unit of Acheson Industries, Philadelphia 3, Pa. (A, D)
★Ackerman Gould Co., Oceanside, N. Y. (C)
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (B, J)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (B)
All Purpose Roll Leaf Corp., Paramus, N. J. (C)
Alpha Chemical & Plastics Corp., Newark 5, N. J. (A)
Aluminum Co. of America, Pittsburgh 19, Pa. (I)
★American Cyanamid Co., Organic Chemicals Div., Dyes Dept., Bound Brook, N. J. (B)
★American Cyanamid Co., Pigments Div., Bound Brook, N. J. (G, H, I, J)
★American Molding Powder & Chemical Corp., Brooklyn 6, N. Y. (A)
Ansbacher-Siegle Corp., Rosebank 5, Staten Island (A, D, J)
Applied Plastics Co., Inc., El Segundo, Calif. (A)
★Argenta Products Co., Garnerville, N. Y. (F)
★Argus Chemical Corp., Brooklyn 31, N. Y. (I)
Aries Laboratories, Inc., Long Island City, N. Y. (D)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (A, B, H, I, J)
★Bee Chemical Co., Chicago 33, Ill. (E, F)
Bios Laboratories, Inc., New York 23, N. Y. (A, B, C, D, E, F, G, H, I, J)
★Blane Corp., The, Canton, Mass. (A)
Brilhart Plastics Corp., Mineola, N. Y. (D, E)
★Cabot, Godfrey L., Inc., Boston 10, Mass. (G)
Carbic Color & Chemical Co., Inc., New York, N. Y. (J)
Carbon Dispersions, Inc., Newark 12, N. J. (A)
★Cassella Farbwerke Mainkur, A. G., Frankfurt/Main, West Germany (B, J)
Century Dispersions, Inc., Detroit 38, Mich. (A)
Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif. (A)
Claremont Pigment Dispersion Corp., Roslyn Heights, N. Y. (A, D, F, H, I)
Colorite Industrial Dyers, New York 18, N. Y. (B)
★Columbian Carbon Co., New York 17, N. Y. (A, G)
Crescent Bronze Powder Co., Chicago 10, Ill. (F, I)
Davis, Frank D., Co., Nixon, N. J. (G)
★Dow Chemical Co., The, Midland, Mich. (B, J)
★Drakenfeld, B. F., & Co., Inc., New York 7, N. Y. (G)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, B, E, G, I, J)
Eagle-Picher Co., The, Cincinnati 1, Ohio (G, I)
★English Mica Co., The, Stamford, Conn. (G)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (G)
★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (J)
Farrington Texol Corp., Walpole, Mass. (A)
★Ferro Corp., Color Div., Cleveland 5, Ohio (A, G, I, J)
Filo Color & Chemical Corp., New York 17, N. Y. (A, B, G, H, I, J)
Garan Chemical Corp., Gardena, Calif. (A, B, D, E)
★Geigy, J. R., S.A., Basle 16, Switzerland (J)
General Color Co., Inc., Newark 5, N. J. (G)
★General Dyestuff Co., Sales Div. of General Aniline & Film Corp., New York 14, N. Y. (A, B, J)
General Printing Ink Co., Div. of Sun Chemical Corp., New York 17, N. Y. (D)
★Gering Products, Inc., Kenilworth, N. J. (A)
★Glidden Co., The, Cleveland 14, Ohio (A, E)
★Glidden Co., The, Chemicals-Pigments-Metals Div., Baltimore 26, Md. (G)
★Harshaw Chemical Co., The, Cleveland 6, Ohio (B, G, J)
★Harwick Standard Chemical Co., Akron 5, Ohio (A, G, I, J)
Hastings Plastics, Inc., Santa Monica, Calif. (A, G, I)
Henley & Co., Inc., New York 17, N. Y. (B)
Hilton-Davis Chemical Co., The, Div., Cincinnati 13, Ohio (A, B, G, J)
★Hommel, O., Co., Pittsburgh 30, Pa. (G, I)
Houghton Laboratories, Inc., Olean, N. Y. (A)
Hummel Chemical Co. Inc., New York 6, N. Y. (I)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.1.,, England (B, G, I, J)
Imperial Color Chemical & Paper Corp., Pigment Color Div., Glens Falls, N. Y. (A, G, H, J)
Interchemical Corp., Color & Chemicals Div., Hawthorne, N. J. (A, B, J)
Interchemical Corp., Finishes Div., Newark, N. J. (A, D, E)
Isochem Resins Corp., Providence 9, R. I. (A, D, E)
★Kassel Export Co., Englewood N. J. (I)
Kenrich Corp., Maspeth 78, N. Y. (A)
★Kentucky Color & Chemical Co., Div. of The Harshaw Chemical Co., Louisville, Ky. (A, B)
Kohnstamm, H., & Co., Inc., New York 13, N. Y. (B, G, J)
Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa. (B, J)
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (A, B, D, E, F, G, H , I, J)
Lakeside Plastics Corp., Oshkosh, Wis. (A, D, E)
Landers-Segal Color Co., Brooklyn 31, N. Y. (A, G, J)
★Lawter Chemicals, Inc., Chicago 45, Ill. (A, D, E, H, J)
Leon Chemical Industries, Inc., Warren, Mich. (A)
Liquid Nitrogen Processing Corp., Chester, Pa. (G)
Loon Chemical Industries, Inc., Warren, Mich. (A)
McGean Chemical Co., The, Cleveland 15, Ohio (G)
★Mearl Corp., The, New York 17, N. Y. (F, G, J)
Metals Disintegrating Co., Inc., Elizabeth B, N. J. (I)
Minnesota Mining & Mfg. Co., Chemical Div., St. Paul 6, Minn. (G)
Mol Rez Div., American Petrochemical Corp., Minneapolis 18, Minn. (A)
Monroe Sander Corp., The, Long Island City 1, N. Y. (A, E)
★Muehlstein, H., & Co., New York 17, N. Y. (A)
National Lead Co., N. Y. 6, N. Y. (F)
★National Polymer Products, Inc., Reading, Pa. (A)
New Jersey Zinc Co., The, New York 38, N. Y. (G)
O'Sullivan Rubber Corp., Winchester, Va. (A)
Palmer, Homer W., & Co., Chicago 22, Ill. (D, G, H, I, J)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (A, B, D, E, G, H, I, J)
Pennsylvania Color & Chemical Co., Doylestown, Pa. (A)
Pigment Dispersions Inc., Roselle, N. J. (A, B, E, F, G, H, I, J)
★Plastic Molders Supply Co., Inc., Fanwood, N. J. (A, F, G, H, I, J)
Plastic Molding Powders, Inc., Brooklyn 23, N. Y. (A)
★Plastics Color Co., Chatham, N. J. (A, B, F, G, H, I, J)
Premier Thermo Plastics Co., Jeffersontown, Ky. (A)
Putnam Chemical Corp., Beacon, N. Y. (B, H, J)
Red Spot Paint & Varnish Co., Inc., Evansville 8, Ind. (B, D, E, F, I, J)
★Reed Plastics Corp., Worcester 8, Mass. (A, B, D, E, F, G, H, I, J)
★Reichhold Chemicals, Inc., White Plains, N. Y. (G)
Rhode Island Laboratories, Inc., West Warwick, R. I. (G, H)

★ Indicates Advertiser

★Riverdale Color Co., Inc., Newark 2, N. J. (B, G, H, I, J)
★Rona Laboratories, Inc., Bayonne, N. J. (A, F, I, J)
Sampson Chemical & Pigment Corp., Chicago 12, Ill. (G, H)
Sandoz, Inc., New York, N. Y. (B, J)
Sartomer Resins, Inc., Philadelphia 4, Pa. (A)
Schwartz Chemical Co., Inc., Long Island City 1, N. Y. (A, B, E, G, I, J)
Silberline Mfg. Co., Inc., Stamford, Conn. (I)
Smith Chemical & Color Co., Inc., Brooklyn 1, N. Y. (A, G, I, J)
Smith, J. Lee, & Co., Inc., New York 38, N. Y. (A, G)
Southern Clays, Inc., New York 6, N. Y. (D, E, G)
Standard Ultramarine & Color Co., Huntington 2, W. Va. (A, G, J)
Stanley Doggett, Inc., New York 13, N. Y. (A, G, H, I, J)
★Sullivan Varnish Co., Chicago 22, Ill. (A, B, E, F)
Switzer Bros., Cleveland 3, Ohio (D, E, H)
Synthetic Chemicals, Inc., Paterson 4, N. J. (B)
Taussig, F. H., New York, N. Y. (F)
Technicraft Co., Boston, Mass. (A, B)
Thalco, Los Angeles 22, Calif. (J)
Titanium Pigment Corp., New York 6, N. Y. (G)
Uhlich, Paul, & Co., Inc., New York 6, N. Y. (J)
Ultra Ray Pearl Essence Co., Hyannis, Mass. (F)
United States Radium Corp., Morristown, N. J. (H)
★Vernon Specialties, Inc., N. Tarrytown, N. Y. (B, E)
Verona Dyestuffs Div. of Verona-Pharma Chemical, Union, N. J. (B, J)
★Westchester Plastics, Inc., Mamaroneck, N. Y. (A)
Whitehouse Reinforced Plastic Co., Fort Worth, Texas (A)
★Whittaker, Clark, & Daniels, Inc., New York 7, N. Y. (G)
Williams, C. K., & Co., E. St. Louis, Ill. (G)
Wilmot & Cassidy, Inc., Brooklyn 22, N. Y. (B)

CURING AGENTS

(See Catalysts)

DESTATICIZERS

Alframine Corp., Paterson 4, N. J.
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
B. X. Plastics, Ltd., London, England
B. T. Babbitt, Inc., New York 22, N. Y.
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany
Beaver Laboratories, Inc., Hollis 23, N. Y.
★Bee Chemical Co., Chicago 33, Ill.
★Chemical Development Corp., Danvers, Mass.
Chemical & Engineering Associates, Upper Darby, Pa.
Edison, S. M., Chemical Co., Chicago 16, Ill.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany
★Fine Organics, Inc., Lodi, N. J.
★Geigy Industrial Chemicals, Yonkers, N. Y.
★Harwick Standard Chemical Co., Akron 5, Ohio
Herbert Products, Inc., Woodhaven 21, N. Y.
Houghton, E. F., & Co., Philadelphia 33, Pa.
★Imperial Chemical Industries, Ltd., Millbank, London, S.W. 1, England
Industrial & Domestic Silicones, Reseda, Calif.
★Johns-Manville, New York 16, N. Y.
Kessler Chemical Co., Inc., Philadelphia 35, Pa.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
L & P Tool Co., Cincinnati 25, Ohio
Merchandise Presentation, Inc., New York 35, N. Y.
Merix Chemical Co., Chicago 49, Ill.
Morton-Withers Chemical Co., Div., Chas. Pfizer & Co., Inc., Greensboro, N. C.
Optics Mfg. Corp., Philadelphia 34, Pa.
Plastic Center, Rochester 4, N. Y.
Polyplastex United, Inc., Union, N. J.
Radiation Applications, Inc., New York 17, N. Y.
★Reed Plastics Corp., Worcester 8, Mass.
Research Sales, Inc., Suffern, N. Y.
Specialty Products Co., Jersey City 2, N. J.
Statikil, Inc., Cleveland 13, Ohio
★Sullivan Varnish Co., Chicago 22, Ill.
Swift & Co., Hammond, Ind.
Synthetic Chemicals, Inc., Paterson 4, N. J.
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y.
United States Radium Corp., Morristown, N. J.
★Witco Chemical Co., Inc., New York 17, N. Y.

EMULSIFYING AND DISPERSING AGENTS

Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., N. Y., N. Y.
Alframine Corp., Paterson 4, N. J.
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y.
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y.
Atlas Powder Co., Wilmington 99, Del.
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany
Callery Chemical Co., Pittsburgh 37, Pa.
Chemical & Engineering Associates, Upper Darby, Pa.
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany
Colorite Industrial Dyers, New York 18, N. Y.
Commercial Solvents Corp., New York, N. Y.
★Dewey & Almy Chemical Co. Div., W. R. Grace & Co., Cambridge 40, Mass.
★Dow Chemical Co., The, Midland, Mich.
Drew, E. F., & Co., Inc., New York 10, N. Y.
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany
Fiber Chemical Corp., Cliffwood, N. J.
★Geigy Industrial Chemicals, Yonkers, N. Y.
★Harwick Standard Chemical Co., Akron 5, Ohio
Henley & Co., Inc., New York 17, N. Y.
Houghton, E. F., & Co., Philadelphia 33, Pa.
★Imperial Chemical Industries, Ltd., Millbank, London, S.W. I., England
★Johns-Manville, New York 16, N. Y.
Kessler Chemical Co., Inc., Philadelphia 35, Pa.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y.
Merix Chemical Co., Chicago 49, Ill.
National Aluminate Corp., Chicago 38, Ill.
Onyx Oil & Chemical Co., Jersey City 2, N. J.
Pennsalt Chemicals Corp., Philadelphia 2, Pa.
Philadelphia Quartz Co., Philadelphia 6, Pa.
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
★Plastics Color Co., Chatham, N. J.
Putnam Chemical Corp., Beacon, N. Y.
★Rohm & Haas Co., Philadelphia 5, Pa.
Sun Oil Co., Philadelphia 3, Pa.
Swift & Co., Hammond, Ind.
Synthetic Chemicals, Inc., Paterson 4, N. J.
Tennessee Corp., Atlanta 9, Ga.
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y.
Virginia Chemical Corp., Lynchburg, Va.
★Witco Chemical Co., Inc., New York 17, N. Y.
Wyandotte Chemicals Corp., Wyandotte, Mich.

MOLD LUBRICANTS

(Release Agents)

Alframine Corp., Paterson 4, N. J.
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y.
Applied Plastics Co., Inc., El Segundo, Calif.
Aries Laboratories, Inc., Long Island City, N. Y.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
B. B. Chemical Co., Cambridge 39, Mass.
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany
★Borco Chemicals, Inc., Chicago, Ill.
Brulin & Co., Inc., Indianapolis 7, Ind.
Chase Chemical Corp., Pittsburgh 1, Pa.
Chemical & Engineering Associates, Upper Darby, Pa.
★Chemical Development Corp., Danvers, Mass.
Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif.
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany
Dennis Chemical Co., St. Louis 3, Mo.
★Devcon Corp., Danvers, Mass.
★Dow Chemical Co., The, Midland, Mich.
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.
Ellen Products Co., Haverstraw, N. Y.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany
★Ferro Corp., Color Div., Cleveland 5, Ohio
★Fine Organics, Inc., Lodi, N. J.
Garan Chemical Corp., Gardena, Calif.
★Geigy Industrial Chemicals, Yonkers, N. Y.
★General Electric Co., Silicone Products Dept., Waterford, N . Y.

★ Indicates Advertiser

★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn.
Harms, Perc E., Co., Northfield, Ill.
★Harwick Standard Chemical Co., Akron 5, Ohio
Hastings Plastics, Inc., Santa Monica, Calif.
Houghton, E. F., & Co., Philadelphia 33, Pa.
Houghton Laboratories, Inc., Olean, N. Y.
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England
Industrial & Domestic Silicones, Reseda, Calif.
★Injection Molders Supply Co., Cleveland 20, Ohio
Interchemical Corp., Finishes Div., Newark, N. J.
Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
Lakeside Plastics Corp., Oshkosh, Wis.
Lami-Plast Products Co., Tampa 3, Fla.
★Lanair Co., Chicago 10, Ill.
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass.
Lebec Chemical Corp., Paramount, Calif.
Lunn Laminates, Inc., Huntington Station, N. Y.
Magnolia Plastics, Inc., Chamblee, Ga.
Mallinckrodt Chemical Works, St. Louis 7, Mo.
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y.
Merix Chemical Co., Chicago 49, Ill.
Midland Adhesive & Chemical Corp., Ferndale 20, Mich.
Mol Rez Div., American Petrochemical Corp., Minneapolis 18, Minn.
★Nopco Chemical Co., N. Arlington, N. J.
★Nuodex Products Co., Div. Heyden Newport Chemical Corp., Elizabeth, N. J.
Oakite Products, Inc., New York 6, N. Y.
★Omni Products Corp., New York 16, N. Y.
Onyx Oil & Chemical Co., Jersey City 2, N. J.
Para Products Div., Foundry Rubber, Inc., Washington 16, D. C.
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
★Plastics Color Co., Chatham, N. J.
Polyplastex United, Inc., Union, N. J.
Ren Plastics, Inc., Lansing 9, Mich.
Research Sales Inc., Suffern, N. Y.
Schwartz Chemical Co., Inc., Long Island City 1, N. Y.
Specialty Products Co., Jersey City 2, N. J.
Sprits, Lynbrook, New York
Sun Oil Co., Philadelphia 3, Pa.
Swift & Co., Hammond, Ind.
Synthetic Chemicals, Inc., Paterson 4, N. J.
★Synthetic Products Co., Cleveland 12, Ohio.
Technicraft Co., Boston 34, Mass.
Thalco, Los Angeles 22, Calif.
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y.
★Union Carbide Corp., Silicones Div., New York 17, N. Y.
★United States Gypsum Co., Chicago, Ill.
★Whittaker, Clark & Daniels, Inc., New York 7, N. Y.
★Witco Chemical Co., Inc., New York 17, N. Y.

★ Indicates Advertiser

ODORANTS AND DEODORANTS

Dodge & Olcott, Inc., New York 14, N. Y.
★Dow Chemical Co., The, Midland, Mich.
Fritzsche Brothers, Inc., N. Y. 11, N. Y.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
Merix Chemical Co., Chicago 49, Ill.
★Monsanto Chemical Co., Organic Chemicals Div., St. Louis 66, Mo.
Oakite Products, Inc., N. Y. 6, N. Y.
Penick, S. B., & Co., New York 8, N. Y.
★Reed Plastics Corp., Worcester 8, Mass.
Sindar Corp., New York 36, N. Y.
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., N. Y. 17, N. Y.

PIGMENTS

(See Colors and Colorants)

PLASTICIZERS

A. *Abietates*
B. *Adipates*
C. *Biphenyls*
D. *Camphor*
E. *Citrates*
F. *Fatty Acid Esters (Oleates, etc.)*
G. *Glycerol; Glycol Compounds*
H. *Glycolates*
I. *Hydrocarbons*
J. *Levulinates*
K. *Phosphates*
L. *Phthalates*
M. *Polyester*
N. *Rubbers*
O. *Sebacates and Isosebacates*
P. *Succinates*
Q. *Sulfonamide*

★Advance Solvents & Chemical, Div. of Carlisle Chemical Works, Inc., New Brunswick, N. J. (F, G, L)
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., New York 17, N. Y. (F)
Alkydol Laboratories, Inc., Cicero 50, Ill. (M)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (B, I, L, M, O)
Amoco Chemicals Corp., Chicago 80, Ill. (I)
Archer-Daniels-Midland Co., Minneapolis 2, Minn. (M)
★Argus Chemical Corp., Brooklyn 31, N. Y. (F, J, L)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (B, G, L, M, Q)
Baker Castor Oil Co., The, Bayonne, N. J. (F, M)
Bios Laboratories, Inc., New York 23, N. Y. (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (B, L,O)
Celanese Corp. of America, Chemical Div., New York 16, N. Y. (K, L)
★Chemische Werke Hüls, A. G., Marl (Kreis Recklinghausen), West Germany (L)
★Columbian Carbon Co., N. Y., N. Y. (P)
Commercial Solvents Corp., New York, N. Y. (F, L)
Continental Oil Co., N. Y. 20, N. Y. (I)
Darling & Co., Chicago, Illinois (F, G)
★Deecy Products Company, Cambridge 42, Mass. (B, F, G, L, M, O)
★Dewey & Almy Chemical Co. Div., W. R. Grace & Co., Cambridge 40, Mass. (L, O)
★Diamond Alkali Co., Cleveland 14, Ohio (I)
★Dow Chemical Co., The, Midland, Mich. (C, G, H, I, M)
Drew, E. F., & Co., Inc., New York 10, N. Y. (F, G, M)
Eastman Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (B, L, M, O)
★Emery Industries, Inc., Cincinnati, Ohio (F, G, M, N)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (B, K, L, N)
★Food Machinery & Chemical Corp., Chemicals & Plastics Div., New York 17, N. Y. (B, F, K, L)
Foremost Food & Chemical Co., El Dorado Div., Oakland, Calif. (F, G)
★Frank, J. P., Chemical Corp., Brooklyn 34, N. Y. (B, L)
★Geigy, J. R., S.A., Basel 16, Switzerland (L, M, O)
★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn. (F)
★Goodrich, B. F., Chemical Co., Cleveland 15, Ohio (B, L)
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y. (K, L)
★Harchem Div., Wallace & Tiernan, Inc., Belleville 9, N. J. (B, F, L, N, O)
★Harwick Standard Chemical Co., Akron 5, Ohio (B, F, G, K, L)
Hastings Plastics, Inc., Santa Monica, Calif. (G, M, N)
Henley & Co., Inc., N. Y., N. Y. (D, I)
★Hercules Powder Co., Inc., Wilmington 99, Del. (A, L)
★Hooker Chemical Corp., Niagara Falls, N. Y. (F)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (B, M)
Kay-Fries Chemicals, Inc., New York 16, N. Y. (L)
Kenrich Corp., Maspeth 78, N. Y. (I)
Kessler Chemical Co., Inc., Philadelphia 35, Pa. (B, F, G, L, O, P)
Kolker Chemical Corp., Newark 5, N. J. (B, F, I, K, L, M)
★Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa. (I, L)
L & P Tool Co., Cincinnati 25, Ohio (F)
★Lawter Chemicals, Inc., Chicago 45, Ill. (Q)
Marcus Ruth Jerome Co., Chicago 4, Ill. (F, G)
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y. (D, E, G, I, K, L)
★Monsanto Chemical Co., Organic Chemicals Div., St. Louis 66, Mo. (B, C, H, I, K, L, M, Q)
Morton-Withers Chemical Co., Div., Chas. Pfizer & Co., Inc., Greensboro, N. C. (B, E, F, G, L, M, N)
★Muehlstein, H., & Co., New York 17, N. Y. (L)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (A, B, K, L, N, O)
Penick, S. B., & Co., N. Y., N. Y. (P)
Pennsylvania Industrial Chemical Corp., Clairton, Pa. (I)
★Reichhold Chemicals, Inc., White Plains, N. Y. (B, F, L, O)
★Rohm & Haas Co., Philadelphia 5, Pa. (M, O)
★Rubber Corp. of America, Hicksville, N. Y. (B, F, G, L, M, N, O)
Sun Oil Co., Philadelphia 3, Pa. (I)

Swift & Co., Hammond, Ind. (F, G)
Switzer Bros., Cleveland 3, Ohio (A)
Technicraft Co., Boston 34, Mass. (K, L)
Tennessee Products & Chemical Corp., Nashville, Tenn. (G)
Thiokol Chemical Corp., Trenton 7, N. J. (A, B, N)
Thompson Chemical Co., Pawtucket, R. I. (B, F, L)
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, G, H, K, L, M)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (B, I, M)
★Witco Chemical Co., Inc., New York 17, N. Y. (F, L)

SOLVENTS

A. Alcohols
B. Amides and Amines
C. Esters
D. Ethers
E. Furans
F. Halogenated Compounds
G. Hydrocarbons
H. Ketones
I. Nitrohydrocarbons
J. Sulfur Compounds

Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., New York 17, N. Y. (A)
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (A, H)
Allied Chemical Corp., Nitrogen Div., New York 6, N. Y. (A, B)
★Allied Chemical Corp., Plastics & Coal Chemicals Div., New York 6, N. Y. (C, G)
Amoco Chemicals Corp., Chicago 80, Ill. (G)
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y. (H)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein West Germany (A, B, C, D, E, H)
Bios Laboratories, Inc., New York 23, N. Y. (A, B, C, D, E, F, G, H, I, J)
Borden Chemical Co., The, New York 17, N. Y. (C)
Callery Chemical Co., Pittsburgh 37, Pa. (C)
Celanese Corp. of America, Chemical Div., New York 16, N. Y. (A, C, H)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (A, B, C, D, F, H)
Colorite Industrial Dyers, New York 18, N. Y. (A, F)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Cleveland 14, Ohio (C)
★Columbian Carbon Co., New York 17, N. Y. (B, H)
Commercial Solvents Corp., New York, N. Y. (A, B, C, F, G, H, I)
★Deecy Products Company, Cambridge 42, Mass. (C)
Dennis Chemical Co., St. Louis 3, Mo. (A, C, D, G, H)
★Diamond Alkali Co., Cleveland 14, Ohio (F, H)
★Dow Chemical Co., The, Midland, Mich. (B, C, D, F, G)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, B, C, E, F, G, H)
Eastman Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (A, C, H)
★Enjay Co., Inc., New York 2, N. Y. (A, C, D, H)
★Farbwerke Hoechst AG. (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany (A, C, F, G, H)
Gulf Oil Corp., Petrochemicals Dept., Pittsburgh 30, Pa. (A)
★Harchem Div., Wallace & Tiernan, Inc., Belleville 9, N. J. (A)
Hastings Plastics, Inc., Santa Monica, Calif. (A, G, H)
Henley & Co., Inc., New York 17, N. Y. (D, G, H, J)
★Hercules Powder Co., Inc., Wilmington 99, Del. (H)
★Hooker Chemical Corp., Niagara Falls, N. Y. (F)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (A, B, C, D, F, G, H)
Kay-Fries Chemicals, Inc., New York 16, N. Y. (C)
Kenrich Corp., Maspeth 78, N. Y. (G)
Kolker Chemical Corp., Newark 5, N. J. (C, F)
★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (G)
Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa. (G)
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (G, H)
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y. (A, B, C, D, F, G, H, J)
★Monsanto Chemical Co., Organic Chemicals Div., St. Louis 66, Mo. (A, C, F, G)
Pennsalt Chemicals Corp., Philadelphia 2, Pa. (A, B, C, F, G, J)
Pierce & Stevens Chemical Corp., Buffalo 3, N. Y. (A, C, D, F, G, H)
Quaker Oats Co., The, Chemicals Div., Chicago 54, Ill. (A, E)
★Reichhold Chemicals, Inc., White Plains, N. Y. (A)
★Shell Chemical Corp., New York 20, N. Y. (A, H)
Sinclair Petrochemicals, Inc., New York 20, N. Y. (G)
Slomons Laboratories, Inc., Long Island City 1, N. Y. (H)
Sun Oil Co., Philadelphia 3, Pa. (G)
Synthetic Chemicals, Inc., Paterson 4, N. J. (B)
Tennessee Products & Chemical Corp., Nashville, Tenn. (A, F, G, I)
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York, N. Y. (A, B, C, D, F, G, H, J)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (A, B, C, D, F, G, H)
Union Oil Co. of California, Los Angeles 54, Calif. (G)
★U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., New York 16, N. Y. (A, C, D, F, G, H)

STABILIZERS

A. Light
B. Heat

★Advance Solvents & Chemical, Div. of Carlisle Chemical Works, Inc., New Brunswick, N. J. (A, B)
Alframine Corp., Paterson 4, N. J. (A, B)
★American Cyanamid Co., Organic Chemicals Div., Intermediates Dept., Bound Brook, N. J. (A)
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y. (A)
★Argus Chemical Corp., Brooklyn 31, N. Y. (A, B)
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany (A, B)
Baker Castor Oil Co., The, Bayonne, N. J. (A, B)
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany (A, B)
★Columbian Carbon Co., New York 17, N. Y. (A)
★Deecy Products Co., Cambridge 42, Mass. (A, B)
★Dow Chemical Co., The, Midland, Mich. (A)
Eagle-Picher Co., The, Cincinnati 1, Ohio (A, B)
Eastman Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn. (A, B)
Ferro Chemical Corp., Div. of Ferro Corp., Bedford, Ohio (A, B)
★Frank, J. P., Chemical Corp., Brooklyn 34, N. Y. (A, B)
★Geigy, J. R., S.A., Basel 16, Switzerland (A)
★Geigy Industrial Chemicals, Yonkers, N. Y. (A)
★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn. (A, B)
★Harshaw Chemical Co., The, Cleveland 6, Ohio (A, B)
★Harwick Standard Chemical Co., Akron 5, Ohio (A, B)
Hastings Plastics, Inc., Santa Monica, Calif. (A)
★Hercules Powder Co., Inc., Wilmington 99, Del. (A)
Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa. (A)
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif. (A)
★Lawter Chemicals, Inc., Chicago 45, Ill. (A)
Mallinckrodt Chemical Works, St. Louis 7, Mo. (B)
McGean Chemical Co., The, Cleveland 15, Ohio (A)
Merix Chemical Co., Chicago 49, Ill. (A)
★Metal & Thermit Corp., Rahway, N. J. (A, B)
National Lead Co., New York 6, N. Y. (A, B)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (B)
★Nopco Chemical Co., N. Arlington, N. J. (A, B)
★Nuodex Products Co., Div. Heyden Newport Chemical Corp., Elizabeth, N. J. (A, B)
★Reichhold Chemicals, Inc., White Plains, N. Y. (A, B)
Sumner Chemical Co., Div. of Miles Lab., New York 17, N. Y. (A)
Synthetic Chemicals, Inc., Paterson 4, N. J. (A, B)
★Synthetic Products Co., Cleveland 12, Ohio (A, B)
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York, N. Y. (A, B)
Victor Chemical Works, Chicago 6, Ill. (A)
★Witco Chemical Co., Inc., New York 17, N. Y. (A, B)

VULCANIZING AGENTS

★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany
Bios Laboratories, Inc., New York 23, N. Y.
Callery Chemical Co., Pittsburgh 37, Pa.
★Dow Chemical Co., The, Midland, Mich.
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany

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★Harwick Standard Chemical Co., Akron 5, Ohio
Henley & Co., Inc., New York 17, N. Y.
★Hercules Powder Co., Inc., Wilmington 99, Del.
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England
Kenrich Corp., Maspeth 78, N. Y.
Minnesota Mining & Mfg. Co., Chemical Div., St. Paul 6, Minn.
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn.
Pennsalt Chemicals Corp., Philadelphia 2, Pa.

WETTING AGENTS

★Advance Solvents & Chemical, Div. of Carlisle Chemical Works, Inc., New Brunswick, N. J.
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., New York 17, N. Y.
Alframine Corp., Paterson 4, N. J.
★Allied Chemical Corp., National Aniline Div., New York 6, N. Y.
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y.
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany
Bios Laboratories, Inc., N. Y., N. Y.
★Cassella Farbwerke Mainkur, A. G., Frankfurt/Main, West Germany
Chemical & Engineering Associates, Upper Darby, Pa.
★Chemische Werke Hüls, A. G., Marl (Kreis Recklinghausen), West Germany
Colorite Industrial Dyers, New York 18, N. Y.
★Deecy Products Company, Cambridge 42, Mass.
★Dow Chemical Co., The, Midland, Mich.
Drew, E. F., & Co., Inc., N. Y., N. Y.
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.
Farbenfabriken-Bayer, A. G., Leverkusen, West Germany
Fiber Chemical Corp., Cliffwood, N. J.
★Geigy Industrial Chemicals, Yonkers, N. Y.
★Harwick Standard Chemical Co., Akron 5, Ohio
Houghton, E. F., & Co., Philadelphia 33, Pa.
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England
Kessler Chemical Co., Inc., Philadelphia 35, Pa.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
Lancaster Chemical Corp., Carlstadt, N. J.
Leon Chemical Industries, Inc., Warren, Mich.
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y.
Merix Chemical Co., Chicago 49, Ill.
Minnesota Mining & Mfg. Co., Chemical Div., St. Paul 6, Minn.
National Aluminate Corp., Chicago 38, Ill.
★Nopco Chemical Co., N. Arlington, N. J.
Onyx Oil & Chemical Co., Jersey City 2, N. J.
Pennsalt Chemicals Corp., Philadelphia 2, Pa.
★Plastics Color Co., Chatham, N. J.
Putnam Chemical Corp., Beacon, N. Y.
★Reed Plastics Corp., Worcester 8, Mass.
★Rohm & Haas Co., Philadelphia 5, Pa.
Sandoz, Inc., New York 13, N. Y.
Synthetic Chemicals, Inc., Paterson 4, N. J.
Tennessee Corp., Atlanta 9, Ga.
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York, N. Y.
Victor Chemical Works, Chicago 6, Ill.
Wyandotte Chemicals Corp., Wyandotte, Mich.

Film, Sheeting, and Shapes

For list of distributors, see p. 1161

FILM
(Under 10 Mils)

A. Cellophane (Regenerated Cellulose)
B. Cellulose Acetate
C. Cellulose Acetate Butyrate
D. Cellulose Nitrate
E. Cellulose Propionate
F. Cellulose Triacetate
G. Ethyl Cellulose
H. Fluorocarbons
I. Foamed Plastic
J. Methyl Cellulose
K. Nylon (Polyamide)
L. Polyethylene
M. Polyethylene Terephthalate (Polyester)
N. Polypropylene
O. Polyvinyl Acetate
P. Polyvinyl Alcohol
Q. Polyvinyl Butyral
R. Polyvinyl Chloride
S. Polyvinyl Chloride-Acetate
T. Polyvinyl Chloride-Vinylidene Chloride
U. Polyvinyl-Nitrile Rubber
V. Polyvinylidene Chloride
W. Styrene Polymers and Copolymers
X. Styrene, Biaxially Oriented
Y. Multidirectionally Stretched

★Ace Plastic Co., Jamaica 35, N. Y. (B, C)
Acme Laminating & Plastics Co., Inc., Detroit, Mich. (B, C, D, I, R)
Allied Chemical Corp., General Chemical Div., New York 6, N. Y. (H)
American Viscose Corp., Philadelphia 3, Pa. (A)
Aristocrat Plastics, Inc., Newark 3, N. J. (B, C, H, K, L, M)
Armen, Inc., Long Island City 2, N. Y. (H)
Associated Rubber & Plastic Corp., New York 51, N. Y. (R)
★Auburn Plastic Engineering, Chicago 9, Ill. (B, C, H, K, L, R, S, T, V, X)
AviSun Corp., Philadelphia 3, Pennsylvania (N)
Azienda Resine Sintetiche, Turin, Italy (L)
B. X. Plastics, Ltd., London, England (B, D, F, L, R, T, W, X)
★Barron, J. E., Plastics, Inc., Cincinnati 2, Ohio (B, C, F, L)
Bemis Bro. Bag Co., St. Louis 2, Mo. (L)
★Blank, Arthur, & Co., Inc., Boston 15, Mass. (B, F, G, L, R, T)
Bolta Products Div., The General Tire & Rubber Co., Lawrence, Mass. (L, R)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (B, C, G, H, K, L, M, O, P, R, T, W)
★Campco Div. of Chicago Molded Products Corp., Chicago, Ill. (B, C, G, K, L, N, W)
Canadian General-Tower, Ltd., Galt, Ontario (R, S)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (L, R, S)
Canton Containers, Inc., Canton 7, Ohio (L)
Carolan, K. T., & Co., Inc., Orange, N. J. (H)
Carolina Industrial Plastics Div., Essex Wire Corp., Mt. Airy, N. C. (R)
Cee-Jay Extruders, Inc., New Hyde Park, N. Y. (K, L, N)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (B, F, L)
Chase Bag Co., New York 17, N. Y. (L)
Chippewa Plastics Co., Div. of Rexall Drug & Chemical Co., Chippewa Falls, Wis. (K, L, N, X)
Clopay Corp., Cincinnati 14, Ohio (L, R)
★Colonial Kolonite Co., Chicago 47, Ill. (B, C, L, M, N, O, R, S, T)
Columbus Coated Fabrics Corp., Columbus 16, Ohio (R, S)
Commercial Plastics, Ltd., London W.1, England (L, N, R)
★Commercial Plastics & Supply Corp., New York 12, N. Y. (B, C, H, K, L, R, S)
★Continental-Diamond Fibre Corp., Sub. of The Budd Co., Newark, Del. (H)
★Cooke Color & Chemical Co., Hackettstown, N. J. (L)
Crane Packing Co., Morton Grove, Ill. (H)
★Davis, Joseph, Plastics Co., Kearny, N. J. (B, C, D,G, L, N, R, W)
★Dayton Rubber Co., The, Dayton, Ohio (I)
Dixon Corp., Bristol, R. I. (H)
★Dow Chemical Co., The, Midland, Mich. (G, J, L, T, W, X)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, B, H, K, L, M, Q)

★ Indicates Advertiser

★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (L, R, S)
★Eastman Kodak Co., Rochester 4, N. Y. (B, C, F)
Ellay Rubber Co., Los Angeles 24, Calif. (R)
Elm Coated Fabrics Co., Inc., New York 16, N. Y. (R, S, V)
Emerson & Cuming, Canton, Mass. (R)
★Engineered Plastics, Inc., Gibsonville, N. C. (B, D, L)
Erinoid, Ltd., London, England (W)
Extruders, Inc., Hawthorne, Calif. (L)
Fabric Leather Corp., New York 1, N. Y. (R, T)
Farbenfabriken-Bayer, A. G., Leverkusen, West Germany (C, F)
Fasson Products, Painesville, Ohio (B, I, M, R, X)
Favorite Plastic Corp., Brooklyn 1, N. Y. (L)
Federal Industries, Belleville, N. J. (R)
Fersons Industries, Inc., New York 1, N. Y. (R, S)
Firestone Plastics Co., Pottstown, Pa. (L, R)
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio (K, L, N)
Flex-O-Glass, Inc., Chicago, Ill. (L, R)
Food Film, Inc., Caldwell Township, N. J. (H, L)
★Foster Grant Co., Inc., Leominster, Mass. (K, W)
Frank, J. P., & Co., Inc., Brooklyn 34, N. Y. (L)
Freeport Plastic Sheet Corp., Freeport, N. Y. (B)
★Gering Products, Inc., Kenilworth, N. J. (L, N)
Goodrich, B. F., Industrial Products Co., Marietta, Ohio (L, R)
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y. (R, S)
Gore, W. L., & Associates, Newark, Del. (H)
Grace, W. R., & Co., Cryovac Div., Cambridge, Mass. (L, V)
H & R Industries, Nazareth, Pa. (K, L, N, W)
Halogen Insulator & Seal Corp., Franklin Park, Ill. (H)
Harte & Co. Inc., New York, N. Y. (L)
Hedwin Corp., Baltimore, Md. (L, R)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (L)
★Imperial Chemical Industries (Hyde), Ltd., Subsidiary of Imperial Chemical Industries, Ltd., Cheshire, England (R, S)
Industrial Plastic Coating Corp., Clifton, N. J. (H)
Intraplast Mfg. Co., New York 4, N. Y. (L, R)
Joanna Western Mills Co., Plastic Fabrics Div., Chicago 32, Ill. (L, N)
Joclin Mfg. Co., Wallingford, Conn. (H)
Kalle & Co., A.G., Wiesbaden, West Germany (A, K, L, R)
Kal Plastics, Inc., Beaverton, Mich. (L, N)
Keystone Packaging Service, Easton, Pa. (L)
Kleestron, Ltd., London, England (W)
★Kleinewefers, Joh., Söhne, Krefeld, West Germany (L, N, O)
★Koppers Co., Inc., Plastics Div., Durethene Dept., Chicago 38, Ill. (M)
Kordite Corp., Macedon, N. Y. (L)
L & P Tool Co., Cincinnati, Ohio (R)
Lamex, Inc., Norcross, Ga. (L)
Leathertone, Inc., Boston 14, Mass. (B, C, G, L, R, W)
Linehan & Co., Dallas 7, Texas (B)
Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass. (K, L, N)
Marbek, Inc., Brooklyn 22, N. Y. (R)
Maynard Plastics, Inc., Salem, Mass (L, N)
Mazzucchelli Celluloide S.p.A., Castiglione Olona (Varese), Italy (A, B, D, F, L)
Metallic Plastics Corp., Long Island City 1, N. Y. (N, R, S, T, U)
Metropolitan Plastics Corp., Brooklyn 11, N. Y. (L)
Micron Plastics Corp., Brooklyn 38, N. Y. (L)
★Midwest Plastic Products Co., Chicago Heights, Ill. (B, C, L, N, W)
Miracle Adhesives Corp., Bellmore, N. Y. (O, R)
★Mono-Sol Corp., Gary, Ind. (P)
★Monsanto Chemical Co., Plastics Div., Springfield 2, Mass. (B, Q, R, X)
★Muehlstein, H., & Co., New York 17, N. Y. (R, S)
Multi-Stretched Films, Inc., Chicago 2, Ill. (Y)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (L, N, R, S)
Natvar Corp., Woodbridge, N. J. (L, N, X)
★Naugatuck Chemical, Div. of United States Rubber Co., Naugatuck, Conn. (R)
★Nixon Nitration Works, Nixon, N. J. (B, C, D, E, M, N, R, S, W)
★Nopco Chemical Co., N. Arlington, N. J. (I)
Novelty Bias Binding Co., Plastics Div., Chelsea, Mass. (M, N, O, R, S)
Nylon Molding Corp., Garwood, N. J. (H, K)
Olin Mathieson Chem. Corp., Packaging Div., N. Y. 21, N. Y. (A, L)
★Omni Products Corp., New York 16, N. Y. (B, C, R)
Pantasote Co., The, Passaic, N. J. (R, S)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (R)
Pearson Industries, Long Island City 1, N. Y. (N, R, S, T, U)
Permacel, New Brunswick, N. J. (H)
Plastex Process Co., Maywood, N. J. (K)
Plastic Film Co., Inc., New York, N. Y. (L, O, R)
Plastic Horizons, Inc., Paterson, N. J. (L)
Plastic Laminating Corp., Vauxhall, N. J. (B, S)
Plax Corp., Hartford 1, Conn. (W, X)
Plicose Mfg. Corp., Brooklyn 22, N. Y. (L, N)
Polyken Sales Div., The Kendall Co., Chicago 6, Ill. (L, M)
★Polymer Corp. of Pa., Reading, Pa. (H, K)
Polypenco, Inc., Reading, Pa. (H, K)
Poly Plastic Products, Inc., Paterson 4, N. J. (L)
Polytex Corp., Hoboken, N. J. (L, R)
Presto Plastic Products Co., Inc., Brooklyn 34, N. Y. (R)
Protective Lining Corp., Brooklyn 31, N. Y. (B, L, S)
Rand Rubber Co., Brooklyn 16, N. Y. (R)
★Raritan Plastics Corp., Paterson 1, N. J. (L, W)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (H, L, M)
Reeves Bros., Inc., New York 18, N. Y. (K, N)
Reliance Plastic & Chemical Corp., Paterson 26, N. J. (L)
Reynolds Metal Co., Plastics Div., Richmond 28, Va. (P)
★Robeco Chemicals, Inc., New York 10, N. Y. (R)
Ross & Roberts, Inc., Stratford, Conn. (L, R)
Rowland Products, Inc., Kensington, Conn. (B, C, D, R)
★Rubber Corp. of America, Hicksville, N. Y. (R, S)
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y. (R)
St. Regis Paper Co., Panelyte Div., Yonkers, N. Y. (L)
Sanford Plastics Corp., Matawan, N. J. (H)
Sawaya Manufacturing Co., Inc., Trinidad, Colo. (L)
★Scranton Plastic Laminating Corp., Scranton 5, Pa. (B, C, L, S)
Seal-Peel, Inc., Royal Oak, Mich. (C, G)
★Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio (L, N, R, S)
Shamban, W. S., & Co., Culver City, Calif. (K, N)
★Southern Plastics Co., Columbia 1, S. C. (B, C, G, J, K, L, N, O, R, S, W)
Sun Steel Co., Chicago 36, Ill. (R)
Technical Tape Corp., New Rochelle, N. Y. (L)
Tex-Trude, Inc., Houston 17, Texas (L)
Thalco, Los Angeles 22, Calif. (P, R)
Trans-Poly Corp., Mt. Vernon, N. Y. (M)
★Transilwrap Co., Chicago 40, Ill. (A, B, C, F, K, L, P, R, X)
Tupper Co., Woonsocket, R. I. (L, N)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (L, R, S)
★Union Carbide Plastics Co., Div. of Union Carbide Corp., New York 17, N. Y. (Q, S)
★United States Gasket Co., Plastics Div. of The Garlock Packing Co., Camden, N. J. (H)
Usines Gheysen, S.A., Lembecq-Hal, Belgium (L, R, S, U, W)
Virginia Plak Co., New York, N. Y. (S)
Visking Co., Div. of Union Carbide Corp., Chicago 38, Ill. (L)
Worbla, Ltd., Papiermuhle-Bern, Switzerland (R, S)

FILM, EMBOSSED

Aacon Industries, Inc., Brooklyn 24, N. Y.
Associated Rubber & Plastic Corp., New York 51, N. Y.
Barr Corp., The, Richmond Hill, N. Y.
Bolta Products Div., The General Tire & Rubber Co., Lawrence, Mass.
Bostrom Corp., Milwaukee 4, Wis.
Brutier Product Co., Inc., Secaucus, N. J.
Canadian General-Tower, Ltd., Galt, Ontario
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que.
Canton Containers, Inc., Canton 7, Ohio
Clopay Corp., Cincinnati 14, Ohio
Coating Products, Inc., Englewood, N. J.
Columbus Coated Fabrics Corp., Columbus 16, Ohio
Commercial Plastics, Ltd., London W.1, England
Crowl, Charles, Co., El Monte, Calif.
Dorrie Process Co., Inc., Brooklyn 22, N. Y.
★Dow Chemical Co., The, Midland, Mich.
Efka Plastic Corp., Hoboken, N. J.
Elm Coated Fabrics Co., Inc., New York 16, N. Y.
Extruders, Inc., Hawthorne, Calif.
Fabric Leather Corp., New York 1, N. Y.

★ Indicates Advertiser

Firestone Plastics Co., Pottstown, Pa.
Flexcon Co., Spencer, Mass.
Gomar Mfg. Co., Inc., Linden, N. J.
Goodrich, B. F., Industrial Products Co., Marietta, Ohio
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y.
Harte & Co., Inc., New York 16, N. Y.
Hedwin Corp., Baltimore 11, Md.
★Imperial Chemical Industries (Hyde), Ltd., Subsidiary of Imperial Chemical Industries, Ltd., Cheshire, England
Intraplast Mfg. Co., New York 4, N. Y.
Joanna Western Mills Co., Plastic Fabrics Div., Chicago 32, Ill.
Kalle & Co., A.G., Wiesbaden, West Germany
★Koppers Co., Inc., Plastics Div., Durethene Dept., Chicago 38, Ill.
Leatherstone, Inc., Boston 14, Mass.
Marbec, Inc., Brooklyn 22, N. Y.
Metallic Plastics Corp., Long Island City 1, N. Y.
Pantasote Co., The, Passaic, N. J.
Pearson Industries, Long Island City 1, N. Y.
Plicose Mfg. Corp., Brooklyn 22, N. Y.
Polyken Sales Div., The Kendall Co., Chicago 6, Ill.
Polytex Corp., Hoboken, N. J.
Presto Plastic Products Co., Inc., Brooklyn 34, N. Y.
Ridge Printing Co., Inc., Ridgefield, N. J.
★Robeco Chemicals, Inc., New York 10, N. Y.
Ross & Roberts, Inc., Stratford, Conn.
★Rubber Corp. of America, Hicksville, N. Y.
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y.
Sun Steel Co., Chicago 36, Ill.
Therm-O-Form Plastics Co., Homewood, Ill.
★Transilwrap Co., Chicago, Ill.
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y.
★United States Gasket Co., Plastics Div. of The Garlock Co., Camden, N. J.
Usines Gheysen, S.A., Lembecq-Hal, Belgium
Visking Co., Div. of Union Carbide Corp., Chicago 38, Ill.

FILM, METALLIZED

Aacon Industries, Inc., Brooklyn, N. Y.
Acme Laminating & Plastics Co., Inc., Detroit, Mich.
All Purpose Roll Leaf Corp., Paramus, N. J.
Brutier Product Co., Inc., Secaucus, N. J.
Coating Products, Inc., Englewood, N. J.
Commercial Plastics, Ltd., London W.1, England
Dorrie Process Co., Inc., Brooklyn 22, N. Y.
Fabric Leather Corp., New York 1, N. Y.
Fasson Products, Painesville, Ohio
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio
Gomar Mfg. Co., Inc., Linden, N. J.
Hastings & Co., Inc., Philadelphia 3, Pa.
★Imperial Chemical Industries (Hyde), Ltd., Subsidiary of Imperial Chemical Industries, Ltd., Cheshire, England
Joclin Mfg. Co., Wallingford, Conn.
Lamart Corp., Clifton, N. J.
Marbek, Inc., Brooklyn 22, N. Y.
Metallic Plastics Corp., Long Island City 1, N. Y.
Pearson Industries, Long Island City 1, N. Y.
Polyken Sales Div., The Kendall Co., Chicago 6, Ill.
Vacuum Technik, Niederwalluf, West Germany.

FILM, PERFORATED

Aacon Industries, Inc., Brooklyn, N. Y.
Acme Laminating & Plastics Co., Inc., Detroit, Mich.
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que.
Canton Containers, Inc., Canton 7, Ohio
Coating Products, Inc., Englewood, N. J.
Columbus Coated Fabrics Corp., Columbus 16, Ohio
Extruders, Inc., Hawthorne, Calif.
Fabric Leather Corp., New York, N. Y.
Kordite Corp., Macedon, N. Y.
Metallic Plastics Corp., Long Island City 1, N. Y.
Pearson Industries, Long Island City 1, N. Y.
Plicose Mfg. Corp., Brooklyn 22, N. Y.
Polyken Sales Div., The Kendall Co., Chicago 6, Ill.
Presto Plastic Products Co., Inc., Brooklyn 34, N. Y.
Reynolds Metal Co., Plastics Div., Richmond 28, Va.
Shamban, W. S., & Co., Culver City, Calif.
★Transilwrap Co., Chicago, Ill.
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y.
Usines Gheysen, S.A., Lembecq-Hal, Belgium
Visking Co., Div. of Union Carbide Corp., Chicago 38, Ill.

LAMINATES

(Film-to-Film, Film-to-Paper, etc.)

Aacon Industries, Inc., Brooklyn 24, N. Y.
Armen, Inc., Long Island City 2, N. Y.
Barr Corp., The, Richmond Hill, N. Y.
★Blank, Arthur & Co., Inc., Boston, Mass.
Canadian General-Tower, Ltd., Galt, Ontario
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que.
Chemtron Fiber Glass Co., El Monte, Calif.
Clopay Corp., Cincinnati 14, Ohio
Coating Products, Inc., Englewood, N. J.
Columbus Coated Fabrics Corp., Columbus 16, Ohio
Commercial Plastics, Ltd., London W.1., England
Consolidated Plastic Sales Co., St. Louis 23, Mo.
Contour Packaging Co., Philadelphia 27, Pa.
Cromwell Paper Co., Chicago 1, Ill.
Crowl, Charles, Co., El Monte, Calif.
Curry Arts, Scranton 9, Pa.
★Davis, Joseph, Plastics Co., Kearny, N. J.
Dorrie Process Co., Inc., Brooklyn 22, N. Y.
Efka Plastic Corp., Hoboken, N. J.
Electro-Technical Products Div., Sun Chemical Corp., Nutley 10, N. J.
Elm Coated Fabrics Co., Inc., New York 16, N. Y.
Fabric Leather Corp., New York 1, N. Y.
Fasson Products, Painesville, Ohio
Fersons Industries, Inc., New York 1, N. Y.
Flexcon Co., Spencer, Mass.
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio
Gomar Mfg. Co., Inc., Linden, N. J.
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y.
H & R Industries, Nazareth, Pa.
Harte & Co., Inc., New York 16, N. Y.
★Imperial Chemical Industries (Hyde), Ltd. Sub. of Imperial Chemical Industries, Ltd., Cheshire, England
Intraplast Mfg. Co., New York 4, N. Y.
Joanna Western Mills Co., Plastic Fabrics Div., Chicago 32, Ill.
Kaykor Industries, Inc., Yardville, N. J.
Lamart Corp., Clifton, N. J.
Leathertone, Inc., Boston 14, Mass.
Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass.
Marbek, Inc., Brooklyn 22, N. Y.
Metallic Plastics Corp., Long Island City 1, N. Y.
Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn.
Pantasote Co., The, Passaic, N. J.
Pearson Industries, Long Island City 1, N. Y.
Plastic Film Co., Inc., New York, N. Y.
Plastic Laminating Corp., Vauxhall, N. J.
Polyplastex United, Inc., Union, N. J.
Presto Plastic Products Co., Inc., Brooklyn 34, N. Y.
Protective Lining Corp., Brooklyn 31, N. Y.
Rainier Plywood Co., Tacoma, Wash.
Reynolds Metal Co., Plastics Div., Richmond 28, Va.
Ridge Printing Co., Inc., Ridgefield, N. J.
★Riegel Paper Corp., New York 17, N. Y.
Roltex Process Corp., Roselle, N. J.
Ross & Roberts, Inc., Stratford, Conn.
★Rubber Corp. of America, Hicksville, N. Y.
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y.
St. Regis Paper Co., Panelyte Div., Yonkers, N. Y.
Schjeldahl, G. T., Co., Northfield, Minn.
★Scranton Plastic Laminating Corp., Scranton 5, Pa.
Shamban, W. S., & Co., Culver City, Calif.
Sierracin Corp., The, Burbank, Calif.
★Standard Insulation Co., Inc., E. Rutherford, N. J.
Sun Steel Co., Chicago 36, Ill.
United Laminations, Inc., Mayfield, Pa.
Usines Gheysen, S.A., Lembecq-Hal, Belgium
Virginia Plak Co., New York 16, N. Y.
Wasco Products, Inc., Cambridge 38, Mass.
Willson Camera Co., Havertown, Pa.

LAMINATES, HIGH-PRESSURE

(See p. 1111)

RODS, TUBES, AND SHAPES

A. Acrylate and Methacrylate
B. Casein
C. Cast Phenolic
D. Cellulose Acetate
E. Cellulose Acetate Butyrate
F. Celulose Nitrate
G. Cellulose Propionate
H. Ceramoplastic
I. Ethyl Cellulose
J. Fluorocarbons
K. Glass Bonded Mica
L. Nylon (Polyamide)
M. Polycarbonate
N. Polyester, Cast

★ Indicates Advertiser

O. Polyethylene
P. Polyoxymethylene
Q. Polypropylene
R. Polystyrene
S. Polyvinyl Alcohol
T. Polyvinyl Chloride
U. Polyvinyl Chloride-Acetate
V. Polyvinylidene Chloride
W. Silicones
X. Styrene Copolymers

A.A.A. Plastic Co., New York 17, N. Y. (A, D, E, F, G, I, J, L, O, Q, R, S T, U, X)
Aacon Industries, Inc., Brooklyn, N. Y. (A, C, D, E, N, O, R, T, U, V, X)
★Ace Plastic Co., Jamaica 35, N. Y. (A, C, D, E, I, L, M, O, Q, R, X)
Action Plastics, Inc., Paterson 3, N. J. (E, L, O, T, X)
All-Tech Industries, Miami, Fla. (N)
Alpha Plastics, Inc., Livingston, N. J. (O, Q, T, X)
American Agile Corp., Bedford, Ohio (O, Q, T)
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (D, E, I, L, O, Q, R, T, V, X)
★Anchor Plastics Co., Inc., Long Island City 6, N. Y. (A, D, E, G, I, L, M, O, Q, R, T, X)
★Argenta Products Co., Garnerville, N. Y. (A, D, E, F, G, I, N, O, R, S, T, U, X)
Aristocrat Plastics, Inc., Newark 3, N. J. (O, R)
★Auburn Plastic Engineering, Chicago 9, Ill. (A, D, E, J, L, N, O, R, U, V)
★Auburn Plastics, Inc., Auburn, N. Y. (A, D, E, G, I, L, O, Q, R, T, X)
Azienda Resine Sintetiche, Turin, Italy (O, T)
B. X. Plastics, Ltd., London, England (B, D, L, O, R, T)
★Barron, J. E., Plastics, Inc., Cincinnati 2, Ohio (A, C, E, L, R)
Belon Chemical Co., Inc., Cranston 10, R. I. (O, Q, R, T)
Blum, Paul, Co., Buffalo 10, N. Y. (A)
Bolta Products Div., The General Tire & Rubber Co., Lawrence, Mass. (T)
Borden Chemical, The, Co., New York 17, N. Y. (T, U)
Brilhart Plastics Corp., Mineola, N. Y. (N)
★Busada Mfg. Corp., Flushing 54, N. Y. (E, X)
★Cadillac Plastic & Chemical Co., Detroit, Mich. (A, C, D, E, J, L, O, R, X)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (O)
Carlon Products Corp., Aurora, Ohio (A, D, E, I, L, O)
Carolan, K. T., & Co., Inc., Orange, N. J. (J)
Carolina Industrial Plastics Div., Essex Wire Corp., Mt. Airy, N. C. (T)
★Cast Optics Corp., Hackensack, N. J. (A)
Celluplastic Corp., Newark 2, N. J. (D, E, O, Q)
Chemtron Fiber Glass Co., El Monte, Calif. (C, N)
Chicago Wood & Plastic Products, Chicago 41, Ill. (A, C, E, F, G, I, L, O, R, X)
Clearfloat, Inc., Attleboro, Mass. (A)
★Colonial Kolonite Co., Chicago 47, Ill. (B, C, D, E, K, L, O, R, W, X)
Commercial Plastics Co., Chicago, Ill. (A, B, C, D, E, F, G, I, J, L, O, Q)
Commercial Plastics, Ltd., London W.1, England (T)
★Commercial Plastics & Supply Corp., New York 12, N. Y. (A, D, J, L)
Conneaut Rubber & Plastics Co., Conneaut, Ohio (N, O, Q, R, T, X)
★Continental-Diamond Fibre Corp., Sub. of Budd Co., Newark, Del. (J, K)
★Contour Extrusion Co., Mamaroneck, N. Y. (O, Q)
Corroplast, Inc., Passaic, N. J. (Q, T)
Crane, Robert S., Associates, Columbus 15, Ohio (A, D, E, I, O, R, T, X)
Crane Packing Co., Morton Grove, Ill. (J)
★Crescent Plastics, Inc., Evansville, Ind. (A, E, I, O, Q, R, T, X)
Curry Arts, Scranton 9, Pa. (A, T, X)
Custom Extrusion, Inc., Sheffield, Mass. (A, O, R, T, X)
★Custom Plastics, Inc., Melrose Park, Ill. (D, E, I, O, R, T)
★Davis, Joseph, Plastics Co., Kearny, N. J. (D, E, F, I, O, Q, R, X)
★Dayton Rubber Co., The, Dayton, Ohio (N)
★Decar Plastic Corporation, Middleton, Wis. (W)
★DeWitt Plastics Div., Shoe Form Co., Inc., Auburn, N. Y. (E, O, R)
Dialect, Inc., Fords, N. J. (N)
Dixie Plastics Mfg. Co., New Orleans, La. (E, O, Q, R, T, X)
Dixon Corp., Bristol, R. I . (J)
Duall Plastics, Inc., Athol, Mass. (D, E, I, J, L, O, Q, R, T, X)
★Dumont Corp., San Rafael, Calif. (W)
Du Verre, Inc., Arcade, N. Y. (N)
★Dynamit-Actien-Gessellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (C, D, L, N, R, T, U)
Electronic Mechanics, Inc., Clifton, N. J. (K)
Emerson & Cuming, Inc., Canton, Mass. (N, R, X)
Emerson Plastics, Bronx, N. Y. (N, W)
★Engineered Plastics, Inc., Gibsonville, N. C. (A, D, J, L, O, R)
★Engineering Laboratories, Inc., Pompton Lakes, N. J. (D, R)
Erinoid, Ltd., London, England (A, B, D, L, R, T, X)
Fiberesin Plastics Co., Oconomowoc, Wis. (W)
Geauga Industries Co., Middlefield, Ohio (O, Q, T)
General Plastics, Inc., Kalamazoo, Mich. (O, Q, T, U)
Genesee Laboratory, Inc., Auburn, N. Y. (O, T)
Glasflex, Inc., Stirling, N. J. (A)
Glass Laboratories, Inc., Brooklyn 20, N. Y. (D, E, I, O, Q, R, X)
Goodrich, B. F., Industrial Products Co., Marietta, Ohio (T)
Gore, W. L., & Associates, Newark, Del. (J)
H & R Industries, Nazareth, Pa. (A, L, O, Q, R, V, X)
Halogen Insulator & Seal Corp., Franklin Park, Ill. (J, L)
Haveg Industries, Inc., Wilmington 8, Del. (J, K, T)
Hedwin Corp., Baltimore 11, Md. (O)
Homalite Corp., The, Wilmington 4, Del. (N)
★Hyde, A. L., Co., Grenloch, N. J. (L)
Hydrawlik, Roselle, N. J. (I, O, Q, T)
★Imperial Chemical Industries, Ltd., Millbank, London, England (A)
Industrial Plastic Coating Corp., Clifton, N. J. (J)
Industrial Plastics Corp., Elkhart, Ind. (D, E, I, O, R, T)
Industrial Sales Engineers, N. Y., N. Y. (A, D, E, G, I, L, O, Q, R, S, T, U, X)
Industrial Vinyls, Inc., Miami 42, Fla. (A, E, O, Q, R, T, X)
★Jessall Plastics, Inc., Kensington, Conn. (A, D, E, G, I, L, O, Q, R, T)
Jet Specialties Co., Inc., Los Angeles 63, Calif. (A, D, E, L, O, Q, T, X)
Jodee Plastics, Inc., Brooklyn 8, N. Y. (A, D, E, F, I, L, O, Q, R, T, U, V, X)
★Johns-Manville, New York, N. Y. (J, W)
Kalle & Co., A.G., Wiesbaden, West Germany (T)
Kal Plastics, Inc., Beaverton, Mich. (E, Q)
★Kleinewefers, Joh., Söhne, Krefeld, West Germany (A, D, L, M, O, Q, R, T, U)
Kraloy Plastic Pipe Co., Inc., Los Angeles 22, Calif. (Q, T)
L & P Tool Co., Cincinnati, Ohio (O, T)
Lavorazione Materie Plastiche, S.A.S., Torino, Italy (O, Q, T)
Libbert Plastics, Inc., Fort Worth 14, Texas (E, O, R, T)
Linehan & Co., Dallas 7, Texas (D, E, O, R, U, X)
Lusteroid Container Co., Inc., Maplewood, N. J. (D, E, F, G, O, Q)
Lus-Trus Corp., Ypsilanti, Mich. (A, D, E, I, L, O, Q, R, T, V, X)
Mannesmann-Easton Plastic Products Co., Inc., Easton, Pa. (T)
★Marblette Corp., The, Long Island City 1, N. Y. (C)
Marken Plastic Corp., Los Angeles 59, Calif. (E, Q, R, T, U, X)
Maynard Plastics, Inc., Salem, Mass. (D, E, G, I, O, Q, R, T, U, V, X)
Mayon Plastics, Hopkins, Minn. (O, T)
Mazzucchelli Celluloide S.p.A., Castiglione Olona, Italy (E, F, O, R)
Mica Insulator, Div. of Minnesota Mining & Mfg. Co., Schenectady, N. Y. (W)
Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn. (O,T)
Miracle Adhesives Corp., Bellmore, N. Y. (T)
Moore Mfg. Co., Inc., San Francisco 10, Calif. (O, R, T, U, V, X)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (A, D, E, J, O, Q, R, T, U, V, X)
★Mycalex Corp. of America, Clifton, N. J. (H, K)
★National Plastic Products Co., The, Odenton, Md. (O, R, X)
National Plasticrafters, Inc., Sheboygan, Wis. (E, G, I, O, R, T, U, X)
Natvar Corp. Woodbridge, N. J. (O, Q, T)
New England Tape Co., Hudson, Mass. (D, E, L, Q, R, T)
★Nixon Nitration Works, Nixon, N. J. (D, E, F, G)
Novelty Bias Binding Co., Plastics Div., Chelsea, Mass. (D, E, R, T, U)
Nylon Molding Corp., Garwood, N. J. (J, L)
★Omni Products Corp., New York 16, N. Y. (C, D, E, F, T)
O'Sullivan Rubber Corp., Winchester, Va. (D, E, I, O, Q, R, T, U, X)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (T)
Pen Mac Nye Co., Akron, Ohio (N, T)
Pennsylvania Fluorocarbon Co., Inc., Philadelphia 4, Pa. (J)
Perfex Plastics, Inc., Chicago 16, Ill. (A, D, E, G, I, L, O, Q, R, T, X)
Permacel, New Brunswick, N. J. (J)
Permanent Label Corp., Bloomfield, N. J. (O, P, Q, R, S, T, U)
Plastex Co., The, Columbus 24, Ohio (A, D, E, I, O, R)
Plastic Extruded Products Co., Elizabeth 1, N. J. (O, T)
Plastic Industrial Products, Div. of Carlon Products Corp., Somerville 44, Mass. (L, O, Q, T, U, W, X)
Plastic Process Co., Div. of Monadnock Mills, Los Angeles 45, Calif. (D, E, I, L, O, Q, R, T, X)
★Plastic Stamping and Molding Corp., Chicago, Ill. (A, D, E, J, K, L, N, O, T, U, W, X)

★ Indicates Advertiser

Plastics Industrial Products, Inc., Peabody, Mass. (D, E, O, Q, R, U)
Plastron Specialties, Inc., Los Angeles 21, Calif. (A, D, E, I, J, L, O, Q, R, T, U, X)
Polycast Corp., The, Stamford, Conn. (A, N, R, X)
Poly-Cell Plastics Co., Smithtown, N. Y. (D, Q, R, V)
Polyform Plastics, N. Y., N. Y. (O, T)
★Polymer Corp. of Pa., Reading, Pa. (J, L, M, X)
Polypenco, Inc., Reading, Pa. (J, L, M, X)
Pyramid Plastics, Inc., Chicago 7, Ill. (A, D, E, I, O, R, T, U, V, X)
Quick Plastics, Jackson, Mich. (A, D, E, G, I, L, M, O, Q, R, T, U, X)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (J)
Reeves Bros., Inc., New York 18, N. Y. (L, O, Q)
Reflin Co., San Diego 11, Calif. (N)
Reliance Plastic & Chemical Corp., Paterson 26, N. J. (A, D, E, G, I, J, O, Q, R, T, U, X)
Resincraft Plastics, Inc., Chicago 16, Ill. (O, T)
Resistoflex Corp., Roseland, N. J. (J, S)
Rogers Corp., Rogers, Conn. (J)
Rowland Products, Inc., Kensington, Conn. (D, E, F)
St. Regis Paper Co., Panelyte Div., Yonkers, N. Y. (O)
Sandee Mfg. Co., Chicago 24, Ill. (A, D, E, I, O, R, T, X)
Sanford Plastics Corp., Matawan, N. J. (J)
Sawaya Manufacturing Co., Inc., Trinidad, Colo. (A, N, O)
Schori Process Corp., Long Island City 1, N. Y. (N)
Shamban, W. S., & Co., Culver City, Calif. (J, L, Q)
Sheffield Plastics, Inc., Sheffield, Mass. (Q, T)
Silicone Insulation, Inc., Bronx 61, N. Y. (N, W)
Skyline Industries, Titusville, Pa. (L, O, Q, R, T, X)
★Southern Plastics Co., Columbia 1, S. C. (A, D, E, G, I, L, M, O, Q, R, T, U, X)
Southwestern Plastic Pipe Co., Mineral Wells, Texas (A, E, I, O, Q, R, T, X)
Streamline Plastics Co., New York 12, N. Y. (D, E, G, O, Q, R, X)
★Sunlite Plastics Inc., Milwaukee 46, Wis. (D, E, G, I, L, O, Q, R, T, U, X
Supplex Co., Div. of Amerace Corp., Garwood, N. J. (O, T, U)
Sussex Plastic Co., Belleville, N. J. (A, D, E, G, I, J, O, Q, R, T, U, X)
Taylor Fibre Co., Norristown, Pa. (W)
Tex-Trude, Inc., Houston 17, Texas (E, O, R, T)
★Thermoplastic Processes, Inc., Stirling, N. J. (A, D, E, G, I, O, Q, R, T, V, X)
Thombert, Inc., Newton, Iowa (L, N)
Trans-Poly Corp., Mt. Vernon, N. Y. (O)
★Transilwrap Co., Chicago, Ill. (A, D, E, L, O)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (O)
★United States Gasket Co., Plastics Div. of The Garlock Packing Co., Camden, N. J. (J, L, O, Q)
Usines Gheysen, S.A., Lembecq-Hal, Belgium (T, U)
Vacuum Plastics Corp., Columbus 22, Ohio (R, X)
Valco, Inc., St. Petersburg 3, Fla. (N)
★Vogt Mfg. Corp., Rochester 10, N. Y. (O, Q, R, T, U)
★Waljohn Plastics, Inc., Brooklyn 9, N. Y. (A, D, E, I, O, R, T, X)
Western Plastics Corp., Tacoma 2, Wash. (O, T, X)
Westinghouse Electric Corp., Micarta Div., Hampton, S. C. (W)
Worbla, Ltd., Papiermuhle-Bern, Switzerland (D, E, F, T, U)
World Plastics, New York 60, N. Y. (A, D, E, G, I, O, Q, R, T, U, X)
★Yardley Plastics Co., Columbus 15, O. (A, D, E, G, I, O, Q, R, T, X)
Yates Co., Erie, Pa. (D, E, O, Q, R, T, X)
Young Development Div., Explosives Dept., Hercules Powder Co., Rocky Hill, N. J. (J, Q, W)

SHEETS

(Over 10 Mils)

A. Acrylate and Methacrylate
B. Acrylonitrile-Butadiene-Styrene
C. Allyl
D. Casein
E. Cast Phenolic
F. Cellulose Acetate
G. Cellulose Acetate Butyrate
H. Cellulose Nitrate
I. Cellulose Propionate
J. Cellulose Triacetate
K. Ethyl Cellulose
L. Fluorocarbons
M. Foamed Plastics
N. Glass Bonded Mica
O. Nylon
P. Polycarbonate
Q. Polyester Resins, Cast
R. Polyethylene
S. Polyoxymethylene
T. Polypropylene
U. Polystyrene
V. Polyvinyl Alcohol
W. Polyvinyl Chloride (Plasticized)
X. PVC (Rigid)
Y. Polyvinyl Chloride-Acetate
Z. Polyvinylidene Chloride
AA. Silicones
BB. Styrene Copolymers
CC. Styrene, Oriented
DD. Ceramoplastic

A.A.A. Plastic Co., New York 17, N. Y. (A, B, F, G, I, J, K, O, R, U, BB)
Acadia Synthetic Products, Div. of Western Felt Works, Chicago 23, Ill. (F, G, K, O, R, U, W, AA)
★Ace Plastic Co., Jamaica 35, N. Y. (A, E, F, G, O, P, R, T, U, BB)
Acme Laminating & Plastics Co., Inc., Detroit, Mich. (F, G, H, M, W, BB)
All-Tech Industries, Miami, Fla. (Q)
American Agile Corp., Bedford, Ohio (R, T, W, X)
American Hard Rubber Co., Butler, N. J. (T, W, X, Z, BB)
Aristocrat Plastics, Inc., Newark 3, N. J. (A, F, G, K, L, O, R, U)
Armen, Inc., Long Island City, N. Y. (L)
Armstrong Cork Co., Lancaster, Pa. (M)
Associated Rubber & Plastic Corp., New York 51, N. Y. (W)
★Auburn Plastic Engineering, Chicago 9, Ill. (A, F, G, L, O, Q, R, T, U, W, X, Y, Z)
★Auburn Plastics, Inc., Auburn, N. Y. (A, B, G, R, T, U, W, BB)
B. X. Plastics, Ltd., London, England (D, F, H, R, U, W, X)
★Barron, J. E., Plastics, Inc., Cincinnati, Ohio (A, E, F, G, O)
Belon Chemical Co., Inc., Cranston 10, R. I. (R, W, X)
★Blank, Arthur, & Co., Inc., Boston, Mass. (A, F, W, X)
Blum, Paul Co., Buffalo 10, N. Y. (F, H)
Bolta Products Div., The General Tire & Rubber Co., Lawrence, Mass. (B, R, W, X)
Bostrom Corp., Milwaukee 4, Wis. (W)
Brilhart Plastics Corp., Mineola, N. Y. (M, Q)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (A, B, E, F, (G, H, L, O, Q, R, T, U, W, BB)
★Campco Div. of Chicago Molded Products Corp., Chicago, Ill. (B, F, G, K, O, R, T, U, Y, BB)
Canadian General-Tower, Ltd., Galt, Ontario (W, Y)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (W, X, Y)
Canton Containers, Inc., Canton 7, Ohio (R)
Carolan, K. T., & Co., Inc., Orange, N. J. (L)
Carolina Industrial Plastics Div., Essex Wire Corp., Mt. Airy, N. C. (W, X)
★Carroll, J. B., Co., Chicago 12, Ill. (F, G, R, U, W, X)
★Cast Optics Corp., Hackensack, N. J. (A)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (F, J, R)
Chaney Plastic Molding Co., Denver 16, Colo. (Q)
Chemtron Fiber Glass Co., El Monte, Calif. (E, M, Q)
Chippewa Plastics Co., Chippewa Falls, Wis. (R)
Clopay Corp., Cincinnati 14, Ohio (R)
★Colonial Kolonite Co., Chicago, Ill. (A, E, F, G, N, O, R, U, Y, AA, BB)
Columbus Coated Fabrics Corp., Columbus 16, Ohio (W, X, Y)
Commercial Plastics, Ltd., London W. 1, England (R, T, U, W, X)
★Commercial Plastics & Supply Corp., N. Y., N. Y. (A, F, G, L, O, X, Y, AA)
Conneaut Rubber & Plastics Co., Conneaut, Ohio (B, G, O, R, T, U, W, X, BB)
★Continental-Diamond Fibre Corp., Newark, Del. (L, N, AA)
★Contour Extrusion Co., Mamaroneck, N. Y. (R, T)
Corroplast, Inc., Passaic, N. J. (W, X)
Crane Packing Co., Morton Grove, Ill. (L)
Crowl, Charles, Co., El Monte, Calif. (B, W, X, BB)
Curry Arts, Scranton 9, Pa. (A, W, X)
Custom Extrusion, Inc., Sheffield, Mass. (A, U, BB)
★Custom Plastics, Inc., Melrose Park, Ill. (U, X)
Dart Mfg. Co., Mason, Mich. (B, T, U, BB)
★Davis, Joseph, Plastics Co., Kearny, N. J. (F, G, H, K, R, T, U, X, BB)
Dekoron Products Co., Samuel Moore & Co., Mantua, Ohio (C, K, P)
★DeWitt Plastics Div., Shoe Form Co., Inc., Auburn, N. Y. (G, U)
★Dow Chemical Co., The, Midland Mich. (K, M, R, Z)
★Dumont Corp., San Rafael, Calif. (M, AA)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (Q)

★ Indicates Advertiser

Du Verre, Inc., Arcade, N. Y. (Q)
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (E, F, N, Q, R, U, W, X, Y, BB)
★Eastman Kodak Co., Rochester 4, N. Y. (F, G, J)
Efka Plastic Corp., Hoboken, N. J. (Z)
Electronic Mechanics, Inc., Clifton, N. J. (N)
Ellay Rubber Co., Los Angeles 21, Calif. (W, X)
Elm Coated Fabrics Co., Inc., New York 16, N. Y. (W, Y)
Emerson & Cuming, Inc., Canton, Mass. (M, Q, U, BB)
★Engineered Plastics, Inc., Gibsonville, N. C. (A, F, H, L, O, R)
Erinoid, Ltd., London, England (D, F, U, W, X, BB)
Fabric Leather Corp., New York 1, N. Y. (W)
Falls Hollow Staybolt Co., Cuyahoga Falls, Ohio (L)
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany (AA)
Fersons Industries, Inc., New York 1, N. Y. (W, Y)
Firestone Plastics Co., Pottstown, Pa. (W, X, Y)
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio (O, R, T)
Flex-O-Glass, Inc., Chicago 51, Ill. (G, W, X)
★Foster Grant Co., Inc., Leominster, Mass. (O, BB)
Frank, J. P., & Co., Inc., Brooklyn 34, N. Y. (R)
Freeport Plastic Sheet Corp., Freeport, N. Y. (F)
Garrett Corp., The, Air Cruisers Div., Wall Township, N. J. (R)
★General American Transportation Corp., Plastics Div., Chicago 90, Ill. (T, U, BB)
★General Plastics Corp., Marion, Ind. (A, B, G, R, U, BB)
General Plastics Corp., Paterson, N. J. (L)
General Plastics Mfg. Co., Tacoma 2, Wash. (A, M)
Gilman Brothers Co., The, Gilman, Conn. (B, U, BB)
Gasflex, Inc., Stirling, N. J. (A, C)
Glass Laboratories, Inc., Brooklyn 20, N. Y. (F, G)
Goodrich, B. F., Industrial Products Co., Marietta, Ohio (W, X)
Gordon-Lacey Chemical Products Co., Inc., Maspeth 78, N. Y. (W, Y)
H & R Industries, Nazareth, Pa. (B, O, R, T, X, BB)
Halogen Insulator & Seal Corp., Franklin Pk., Ill. (L)
Haveg Industries, Inc., Wilmington 8, Del. (N, X)
Hedwin Corp., Baltimore, Md. (R, W)
Homalite Corp., The, Wilmington 4, Del. (C, Q)
★Hyde, A. L., Co., Grenloch, N. J. (O)
★Imperial Chemical Industries (Hyde) Ltd., Sub. of Imperial Chemical Industries, Ltd., Cheshire, England (W, Y, BB)
★Imperial Chemical Industries, Ltd., Millbank, London, S.W.I., England (A, X)
Industrial Plastic Coating Corp., Clifton, N. J. (L)
Industrial Sales Engineers, N. Y. 17, N. Y. (A, B, F, G, I, J, K, M, O, R, T, U, X, BB)
Intraplast Mfg. Co., N. Y., N. Y. (W)
Jet Specialties Co., Inc., Los Angeles 63, Calif. (B, G, R, T, U, BB)
Joanna Western Mills Co., Plastic Fabrics Div., Chicago 32, Ill. (R, T)
Joclin Mfg. Co., Wallingford, Conn. (L)
Jodee Plastics, Inc., Brooklyn 8, N. Y. (A, B, F, G, H, I, J, K, O, R, T, U, W, X, Y, Z, BB)
★Johns-Manville, New York 16, N. Y. (L, AA)
Kalle & Co., A.G., Wiesbaden, West Germany (X)
Kal Plastics, Inc., Beavertown, Mich. (B, G, R, T, BB)
Kaykor Industries, Inc., Yardville, N. J. (W, X)
Kent Plastics Corp., Evansville 10, Ind. (U)
Kerr Industries, Burbank Calif. (A, F, G, R, T, U, W, X)
Kleestron, Ltd., London, England (BB)
★Kleinewefers, Joh., Söhne, Krefeld, West Germany (A, F, P, R, T, U, W, X)
★Kurz-Kasch, Inc., Dayton 1, Ohio (L)
Lavorazione Materie Plastiche, S.A.S., Torino, Italy (W, X)
Leathertone, Inc., Boston 14, Mass. (A, F, G, K, W)
Lind Plastic Products, Inc., Chicago 45, Ill. (B, R, BB)
Liquid Nitrogen Processing Corp., Chester, Pa. (M)
Liss Products, Grasmore, N. H. (Q)
Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass. (M)
Lus-Trus Corp., Ypsilanti, Mich. (A, F, G, K, M, R, T, U, BB)
Marbek, Inc., Brooklyn 22, N. Y. (W)
★Marblette Corp., The, Long Island City 1, N. Y. (E)
Masland Duraleather Co., Philadelphia 34, Pa. (W)
Mazzucchelli Celluloide S.p.A., Castiglione Olona (Varese), Italy (F, H, R, U, X, Y, BB)
Metallic Plastics Corp., Long Island City 1, N. Y. (T, X, Y, BB)
★Midwest Plastic Products Co., Chicago Heights, Ill. (A, B, F, G, R, T, U, BB)
★Muehlstein, H., & Co., New York 17, N. Y. (Y)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (R, T, W, X, Y)
★Mycalex Corp. of America, Clifton, N. J. (N, DD)
Nalge Co., Inc., The, Rochester 2, N. Y. (R, T)
★National Plastic Products Co., The, Odenton, Md. (R, U)
★Nixon Nitration Works, Nixon, N. J. (F, G, H, I, R, T, W, X, Y, BB)
★Nopco Chemical Co., N. Arlington, N. J. (M)
Nylon Molding Corp., Garwood, N. J. (L, O)
★Omni Products Corp., New York 16, N. Y. (E, F, G, H, K, X, BB)
O'Sullivan Rubber Corp., Winchester, Va. (A, B, F, G, K, R, T, U, W, Y, BB)
Pantasote Co., Passaic, N. J. (W, X)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (W, X)
Pearson Industries, Long Island City 1, N. Y. (T, X, Y)
Permacel, New Brunswick, N. J. (L)
Plastex Co., The, Columbus 24, Ohio (A, G, U)
Plastex Laminates, Inc., Hialeah, Fla. (A, Q, AA, BB)
Plastex Process Co., Maywood, N. J. (O)
Plastic Laminating Corp., Vauxhall, N. J. (F, Y)
Plastic Process Co., Div. of Monadnock Mills, Los Angeles, Calif. (BB)
★Plastic Stamping and Molding Corp., Chicago 47, Ill. (A, E, F, G, N, O, R, U, AA)
Plastron Specialties, Inc., Los Angeles 21, Calif. (A, F, G, J, K, O, R, T, U, W, BB)
★Plax Corp., Hartford 1, Conn. (U, BB, CC)
Plicose Mfg. Corp., Brooklyn 22, N. Y. (R)
Polycast Corp., The, Stamford, Conn. (A, C, Q, BB)
Polypenco, Inc., Reading, Pa. (L, O, P, BB)
★Polymer Corp. of Pa., Reading, Pa. (L, O, P, BB)
★Portage Plastics Co., Portage, Wis. (R, U, BB)
Presto Plastic Products Co., Inc., Brooklyn 34, N. Y. (W)
Protective Lining Corp., Brooklyn 31, N. Y. (R)
Pyramid Plastics, Inc., Chicago 7, Ill. (Z)
Rand Rubber Co., Brooklyn 16, N . Y. (W)
★Raritan Plastics Corp., Paterson 1, N. J. (B, R, T, U)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (L)
★Reed Plastics Corp., Worcester 8, Mass. (M)
Reliance Plastic & Chemical Corp., Paterson 26, N. J. (R)
Resincraft Plastics, Inc., Chicago 16, Ill. (R, W, X)
Resistoflex Corp., Roseland, N. J. (L, V)
Reynolds Metal Co., Plastics Div., Richmond 28, Va. (V, W)
★Robeco Chemicals, Inc., N. Y., N. Y. (W, X)
Robinson Foams, Ltd., Toronto, Ont. (M)
Rogers Corp., Rogers, Conn. (L)
★Rohm & Haas Co., Philadelphia 5, Pa. (A)
Ross & Roberts, Inc., Stratford, Conn. (R, W, X)
★Rotuba Extruders, Inc., Brooklyn 9, N. Y. (A, F, G, T, U, X, Z, BB)
Rowland Products, Inc., Kensington, Conn. (F, G, H)
★Rubber Corp. of America, Hicksville, N. Y. (W, X, Y)
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y. (W, X)
St. Regis Paper Co., Panelyte Div., Yonkers, N. Y. (R)
St. Regis Paper Co., Panelyte Div., Richmond, Ind. (R, T, U, BB)
Sandee Mfg. Co., Chicago 24, Ill. (A, U, BB)
Sanford Plastics Corp., Matawan, N . J. (L)
Sawaya Mfg. Co., Inc., Trinidad, Colo. (A, O, R)
Schori Process Corp., Long Island City 1, N. Y. (Q)
★Scranton Plastic Laminating Corp., Scranton 5, Pa. (F, G, R, T, U, W, X, Y)
★Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio (R, T, X, Y, BB)
Shamban, W. S., & Co., Culver City, Calif. (L, M, O, T)
Sheffield Plastics, Inc., Sheffield, Mass. (A, U)
Sierracin Corp., Burbank, Calif. (Q)
★Southern Plastics Co., Columbia 1, S. C. (A, B, F, G, I, K, O, P, R, T, U, W, X, Y, BB)
Standard Pyroxoloid Corp., Leominster, Mass. (H)
Sun Steel Co., Chicago 36, Ill. (W)
Thalco, Los Angeles 22, Calif. (V)
★Thermoplastic Processes, Inc., Stirling, N. J. (B, F, G, R, W, X, BB)

★ Indicates Advertiser

★Transilwrap Co., Chicago 40, Ill. (A, F, G, J, L, O, R)
Tri-Point Plastics, Inc., Albertson, N. Y. (L)
Tupper Co., Woonsocket, R. I. (R, U)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (R, W)
★Union Carbide Plastics Co., Div., of Union Carbide Corp., New York 17, N. Y. (Y)
United Progress, Inc., Albany 5, N. Y. (M, U)
U. S. Plastic Products Corp., Metuchen, N. J. (A, Q)
★United States Gasket Co., Plastics Div. of The Garlock Packing Co., Camden, N. J. (L, O, AA)
★United States Rubber Co., Royalite Div., Chicago 39, Ill. (B, U, BB)
Usines Gheysen, S.A., Lambecq-Hal, Belgium (M, W, Y)
Valco, Inc., St. Petersburg 3, Fla. (Q)
Virginia Plak Co., New York 16, N. Y. (X)
Visking Co., Div. of Union Carbide Corp., Chicago 38, Ill. (R)
Vlchek Tool Co., The, Cleveland 4, Ohio (U)
★Waljohn Plastics, Inc., Brooklyn 9, N. Y. (A, G, U)
Wasco Products, Inc., Cambridge 38, Mass. (A, Q)
Weblon, Inc., New York 36, N. Y. (W)
Westinghouse Electric Corp., Micarta Div., Hampton, S. C. (R)
Woodall Industries, Inc., Detroit 34, Mich. (B, M, R, T, U, BB)
Worbla, Ltd., Papiermuhle-Bern, Switzerland (F, H, R, W, X, Y, BB)
World Plastics, New York 60, N. Y. (B, F, G, I, K, R, T, U, W, Y, BB)
Young Development Div., Explosives Dept., Hercules Powder Co., Rocky Hill, N. J. (L, Q, R, T, W, AA)

Fabrics, Papers, Fillers, and Reinforcements

For list of distributors, see p. 1161

COATED AND IMPREGNATED FABRICS

(By Coating Resins)

A. Cellulosic
B. Nylon
C. Polyethylene
D. Polyurethane
E. Rubber
F. Vinyl

American Rattan & Reed Mfg. Co., Great Neck, N. Y. (C)
Associated Rubber & Plastic Corp., New York 51, N. Y. (F)
Bemis Bro. Bag Co., St. Louis 2, Missouri (F)
Birge Co., Inc., The, Buffalo 5, N. Y. (F)
Blossom Mfg. Co., Inc., Brooklyn 3, N. Y. (B, C, F)
Bolta Products Div., The General Tire & Rubber Co., Lawrence, Mass. (F)
Bortman Plastics Co., Boston 11, Mass. (A, F)
Canadian General-Tower, Ltd., Galt, Ont. (F)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (F)
Carpenter, L. E., & Co., Wharton, N. J. (F)
Chemtron Fiber Glass Co., El Monte, Calif. (D)
Columbia Mills, Inc., The, Syracuse 1, N. Y. (F)
Columbus Coated Fabrics Corp., Columbus 16, Ohio (A, E, F)
Cordo Chemical Corp., Norwalk, Conn. (B, E, F)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (A, E, F)
Electro Plastic Fabrics, Inc., Pulaski, Va. (B, F)
Electro-Technical Products Div., Sun Chemical Corp., Nutley 10, N. J. (F)
Elm Coated Fabrics Co., Inc., New York 16, N. Y. (F)
Emerson & Cuming, Inc., Canton, Mass. (E)
Fabric Leather Corp., New York 1, N. Y. (F)
Farrington Texol Corp., Walpole, Mass. (A, E, F)
Federal Industries, Belleville 9, N. J. (F)
Flexfirm Products, S. El Monte, Calif. (E, F)
Goodall-Sanford, Inc., Reading, Mass. (F)
Goodrich, B. F., Industrial Products Co., Akron 18, Ohio (E, F)
Goodrich, B. F., Industrial Products Co., Marietta, Ohio (F)
Gordon-Lacey Chemical Products, Inc., Maspeth 78, N. Y. (E, F)
★Imperial Chemical Industries (Hyde), Ltd., Sub. of Imperial Chemical Industries, Ltd., Cheshire, England (A, D, E, F)
Intraplast Mfg. Co., New York 4, N. Y. (F)
Joanna Western Mills Co., Plastic Fabrics Div., Chicago 32, Ill. (C, F)
★Johns-Manville, New York 16, N. Y. (E)
Jomac, Inc., Philadelphia 38, Pa. (F)
Lamex, Inc., Norcross, Ga. (C)
Laminated Fiberglass Corp. of America, New York 5, N. Y. (C)
Landers Corp., The, Toledo 1, Ohio (E, F)
Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass. (C)
Marbek, Inc., Brooklyn 22, N. Y. (F)
Masland Duraleather Co., Philadelphia 34, Pa. (F)
Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn. (E)
Natvar Corp., Woodbridge, N. J. (D)
Pantasote Co., The, Passaic, N. J. (F)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (F)
Plastic Film Co., Inc., New York, N. Y. (F)
Polyplastex United, Inc., Union, N. J. (F)
Pyrotex Co., Inc., Leominster, Mass. (A, F)
Rand Rubber Co., Brooklyn 16, N. Y. (B, E, F)
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y. (F)
★Sandman, Eli, Co., Worcester 9, Mass. (B, E, F)
Santa Barbara Plastics, Sub. of Narmco Industries, Inc., Goleta, Calif. (F)
★Standard Insulation Co., Inc., E. Rutherford, N. J. (F)
Textileather Div., The General Tire & Rubber Co., Toledo 3, Ohio (A, F)
★Troy Blanket Mills, New York 16, N. Y. (E, F)
Usines Gheysen, S.A., Lembecq-Hal, Belgium (E, F)
Weblon, Inc., New York 36, N. Y. (C, D, F)
White, S. S., Dental Mfg. Co., Industrial Div., New York 16, N. Y. (E)

EXTENDERS

★Cabot, Godfrey L., Inc., Boston 10, Mass.
★Diamond Alkali Co., Cleveland 14, Ohio
★English Mica Co., The, Stamford, Conn.
★Georgia Kaolin Co., Elizabeth, N. J.
Hastings Plastics, Inc., Santa Monica, Calif.
★Johns-Manville, New York 16, N. Y.
Merck & Co., Inc., Rahway, N. J.
★Minerals & Chemicals Corp. of America, Menlo Park, N. J.
Stein, Hall & Co., Inc., New York 17, N. Y.

FABRICS, WOVEN

(For Flexible Laminating)

A. Asbestos
B. Cotton
C. Dacron
D. Fiber Blends
E. Glass
F. Linen

★ Indicates Advertiser

- *G. Misc. Synthetics*
- *H. Nylon*
- *I. Orlon*
- *J. Rayon*

Airconductors, Gardena, Calif. (H)
Barry, B. J., & Co., Inc., N. Y., N. Y. (B)
Bean Fiber Glass Div., D. D. Bean & Sons Co., Jaffrey, N. H. (E)
Bortman Plastics Co., Boston 11, Mass. (B, C, H)
Briscoe Mfg. Co., Columbus, Ohio (E)
Chemtron Fiber Glass Co., El Monte, Calif. (A, C, D, E, I)
★Coast Mfg. & Supply Co., Livermore, Calif. (E)
Exeter Mfg. Co., New York 34, N. Y. (E, G)
★Ferro Corp., Fiber Glass Div., Nashville 11, Tenn. (E)
Fiber Glass Industries, Inc., Amsterdam, N. Y. (E)
★Flightex Fabrics, Inc., New York 13, N. Y. (E)
Garvan, P., Inc., Hartford, Conn. (A, B, C, E)
Hastings Plastics, Inc., Santa Monica, Calif. (E)
Haveg Industries, Inc., Wilmington 8, Del. (A, E)
Hess, Goldsmith & Co., Inc., New York 18, N. Y. (E)
★Johns-Manville, New York 16, N. Y. (A, D, E)
Kish Industries, Inc., Lansing 6, Mich. (B, G)
Laminated Fiberglass Corp. of America, New York 5, N. Y. (B, D, E)
Lane, J. H., & Co., Inc., New York 19, N. Y. (B, I, J)
Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn. (E, H)
★Modiglass Fibers, Inc., Bremen, Ohio (E)
North American Asbestos Corp., Chicago 8, Ill. (A)
★Omni Products Corp., New York 16, N. Y. (E)
Ott, Joseph M. P., Mfg. Co., Pawtucket, R. I. (A, C, D, E, G, I, J)
Pellon Corp., New York 1, N. Y. (B, D, E, G)
★Pittsburgh Plate Glass Co., Fiber Glass Div., Pittsburgh 22, Pa. (E)
Plymouth Cordage Co., Plymouth, Mass. (D)
★Plymouth Fibres, Brooklyn 1, N. Y. (B, C, D, E, F, G, H, I, J)
Rand Rubber Co., Brooklyn 16, N. Y. (B, H, J)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (A, G)
Reeves Bros., Inc., New York 18, N. Y. (G)
Ren Plastics, Inc., Lansing 9, Mich. (E)
★Sandman, Eli, Co., Worcester 9, Mass. (A, B, C, D, E, F, G, H, I, J)
Turner Halsey Co., N. Y., N. Y. (B, D)
United Merchants Industrial Fabrics, New York 18, N. Y. (E)
★United States Gypsum Co., Chicago 6, Ill. (E)
★Wellington Sears Co., Inc., New York 18, N. Y. (B, C, D, G, H, I, J)
Westinghouse Electric Corp., Micarta Div., Hampton, S. C. (F)
★Whittaker, Clark, & Daniels, Inc., New York 7, N. Y. (A, E)

FABRICS, NON-WOVEN

- *A. Asbestos*
- *B. Cotton*
- *C. Felt*
- *D. Fiber Blends*
- *E. Glass*
- *F. Synthetic Fibers*

★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (F)
American Felt, Glenville, Conn. (C)
Bean Fiber Glass Div., D. D. Bean & Sons Co., Jaffrey, N. H. (E)
Chemtron Fiber Glass Co., El Monte, Calif. (D, E)
Felters Co., The, Boston 11, Mass. (C, D, F)
★Ferro Corp., Fiber Glass Div., Nashville 11, Tenn. (E)
Fiber Glass Industries, Inc., Amsterdam, N. Y. (D, E)
Hastings Plastics, Inc., Santa Monica, Calif. (E)
Haveg Industries, Inc., Wilmington 8, Del. (A, E)
★Johns-Manville, New York, N. Y. (A)
Lane, J. H., & Co., Inc., N. Y., N. Y. (F)
Marmyte Co., Mundelein, Ill. (E)
★Modiglass Fibers, Inc., Bremen, Ohio (E)
North American Asbestos Corp., Chicago 8, Ill. (A, D)
★Omni Products Corp., New York 16, N. Y. (E)
Owens-Corning Fiberglas Corp., New York 22, N. Y. (E)
Pellon Corp., New York, N. Y. (D, F)
★Pittsburgh Plate Glass Co., Fiber Glass Div., Pittsburgh 22, Pa. (E)
Plymouth Cordage Co., Plymouth, Mass. (D)
★Plymouth Fibres, Brooklyn, N. Y. (E, F)
Rand Rubber Co., Brooklyn, N. Y. (B)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (A, D)
Rogers Corp., Rogers, Conn. (F)
★Standard-Union Fibre Co., Philadelphia 34, Pa. (D)
★Troy Blanket Mills, New York 16, N. Y. (D, F)
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York, N. Y. (F)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (F)
★Wellington Sears Co., Inc., New York 18, N. Y. (B, D, F)

FIBERS AND MONOFILAMENTS

- *A. Acetate*
- *B. Acrylics*
- *C. Aluminum*
- *D. Asbestos*
- *E. Cellulosic*
- *F. Glass*
- *G. Mineral (Wool)*
- *H. Nylon*
- *I. Polyester*
- *J. Polyethylene*
- *K. Polypropylene*
- *L. Polystyrene*
- *M. Polytetrafluoroethylene*
- *N. Rayon*
- *O. Saran*
- *P. Sisal*
- *Q. Steel*

★Allied Chemical Corp., National Aniline Div., New York 6, N. Y. (H)
Aries Laboratories, Inc., Long Island City, N. Y. (C, D)
AviSun Corp., Philadelphia 3, Pa. (K)
B. X. Plastics, Ltd., London, England (O)
Blum, Paul, Co., Buffalo, N. Y. (F, H)
Bolta Products Div., The General Tire & Rubber Co., Lawrence, Mass. (J, O)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (L)
★Celanese Corp. of America, Fibers Div., Charlotte 1, N. C. (A, N)
★Chemical Development Corp., Danvers, Mass. (C, Q)
Chemtron Fiber Glass Co., El Monte, Calif. (F, P)
Commercial Plastics Co., Chicago 14, Ill. (E, H)
Composition Materials Co., Inc., New York 36, N. Y. (P)
★Cosden Petroleum Corp., Big Spring, Texas (L)
Dawbarn Bros., Inc., Waynesboro, Va. (J, K, O)
★Dow Chemical Co., The, Midland, Mich. (B)
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del. (B, E, H, M, N)
Eagle-Picher Co., The, Cincinnati 1, Ohio (G)
Erinoid, Ltd., London, England (J, L)
★Ferro Corp., Fiber Glass Div., Nashville 11, Tenn. (F)
Flexfirm Products, S. El Monte, Calif. (I)
Hankins Container Co., Div. of The Flintkote Co., Cleveland 35, Ohio (C, D)
Hastings Plastics, Inc., Santa Monica, Calif. (F)
Haveg Industries, Inc., Wilmington 8, Del. (D, F)
International Textile Co., Chicago 39, Ill. (F, P)
Jodee Plastics, Inc., Brooklyn 8, N. Y. (A, B, E, H, J, K, L)
★Johns-Manville, New York 16, N. Y. (D, F, G)
Laminated Fiberglass Corp. of America, New York 5, N. Y. (F)
Lus-Trus Corp., Ypsilanti, Mich. (J, K, O)
★Modiglass Fibers, Inc., Bremen, Ohio (F)
★National Plastic Products Co., The, Odenton, Md. (H, J, K, L, O)
North American Asbestos Corp., Chicago 8, Ill. (D)
★Omni Products Corp., N. Y., N. Y. (F)
Owens-Corning Fiberglas Corp., New York 22, N. Y. (F)
★Pittsburgh Plate Glass Co., Fiber Glass Div., Pittsburgh 22, Pa. (F)
Plastic Industrial Products, Div. of Carlon Products Corp., Somerville 44, Mass. (K)
Plymouth Cordage Co., Plymouth, Mass. (P)
★Plymouth Fibres, Brooklyn 1, N. Y. (H)
Plymouth Industrial Products, Inc., Sheboygan, Wis. (D)
★Powhatan Mining Co., Baltimore 7, Md. (D)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (D, M)
Reeves Bros., Inc., N. Y., N. Y. (J, K)
Ren Plastics, Inc., Lansing 9, Mich. (F)
★Riegel Paper Corp., New York 17, N. Y. (E)
Shamban, W. S., & Co., Culver City, Calif. (H)
★Standard-Union Fibre Co., Philadelphia 34, Pa. (P)
Stein, Hall & Co., Inc., New York 17, N. Y. (P)
★Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York, N. Y. (B)
U. S. Glass Fibre Co., Manchester, Conn. (F)
★United States Gypsum Co., Chicago 6, Ill. (F)
★Whittaker, Clark, & Daniels, Inc., New York 7, N. Y. (D, F)

★ Indicates Advertiser

FIBROUS GLASS, RESIN LOADED

A. Cloth
B. Mat
C. Roving

American Reinforced Plastics Co., Los Angeles 27, Calif. (A, C)
Blum, Paul, Co., Buffalo 10, N. Y. (A)
Chemtron Fiber Glass Co., El Monte, Calif. (A, B)
★Coast Mfg. & Supply Co., Livermore, Calif. (A, B, C)
Electro Plastics Fabrics, Inc., Pulaski, Va. (A)
Electro-Technical Products Div., Sun Chemical Corp., Nutley 10, N. J. (A, B)
★Fabricon Products, Inc., River Rouge, Mich. (A, B, C)
★Famco, Inc., Louisville 9, Ky. (B)
★Ferro Corp., Fiber Glass Div., Nashville 11, Tenn. (B)
Haveg Industries, Inc., Wilmington 8, Del. (A, B, C)
Houze Glass Corp., Point Marion, Pa. (B)
★Johns-Manville, New York 16, N. Y. (A, B)
Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn. (A)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., St. Paul 6, Minn. (C)
★Modiglass Fibers, Inc., Bremen, Ohio (B)
★Omni Products Corp., New York 16, N. Y. (A, B, C)
★Pittsburgh Plate Glass Co., Fiber Glass Div., Pittsburgh 22, Pa. (C)
Polyplastex United, Inc., Union, N. J. (A, B, C)
★Sandman, Eli, Co., Worcester 9, Mass. (A, B, C)
★Standard Insulation Co., Inc., E. Rutherford, N. J. (A, B, C)
★U. S. Polymeric Chemicals, Inc., Stamford, Conn. (A, B, C)

FILLERS

A. Alpha Cellulose
B. Aluminum Silicate
C. Asbestos
D. Calcium Carbonate
E. Carbon Black
F. Chalk
G. Clays
H. Cocoanut Shell Flour
I. Cotton Flock
J. Diatomaceous Earth
K. Fabric (Macerated or Chopped)
L. Glass Fiber, Flakes, and Fabric
M. Graphite
N. Lignin and Lignin Extended Fillers
O. Metallic
P. Mica
Q. Protein Fillers (Soy Bean Meal, Ground Feathers, etc.)
R. Silica
S. Sisal
T. Walnut Shell Flour
U. Wollastonite
V. Wood Flour

Agrashell, Inc., Los Angeles 22, Calif. (T)
Alabama Calcium Products Co., Gantts Quarry, Ala. (D)
American Resin Corp., Chicago 13, Ill. (M)
Aries Laboratories, Inc., Long Island City, N. Y. (C, P, R)
Armco Steel Corp., Middletown, Ohio (D)
Avco Mfg., Research & Advanced Development Div., Wilmington, Mass. (R)
Balsa Ecuador Lumber Corp., New York 36, N. Y. (V)
Basic Plastic Materials, Inc., Winchester, N. H. (A, I)
Bernard Sirotta Co., Brooklyn 31, N. Y. (H, T, V)
Blum, Paul, Co., Buffalo 10, N. Y. (K, L)
Brown Co., Boston 14, Mass. (A)
Buckeye Cellulose Corp., Memphis 8, Tenn. (A)
★Cabot, Godfrey L., Inc., Boston 10, Mass. (E, R, U)
Calcium Carbonate Co., Quincy, Ill. (D)
Campbell, Harry T., Sons' Corp., Baltimore 4, Md. (D)
Carbon Dispersions, Inc., Newark 12, N. J. (E)
Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif. (G, P)
★Chemische Werke Hüls, A. G., Marl (Kreis Recklinghausen), West Germany (E)
Chemtron Fiber Glass Co., El Monte, Calif. (C, G, L, R, S)
Chicago Wood & Plastic Products, Chicago 41, Ill. (V)
★Claremont Flock Corp., Claremont, N. H. (I, K, L)
★Coast Mfg. & Supply Co., Livermore, Calif. (K)
★Columbian Carbon Co., New York 17, N. Y. (E)
Composition Materials Co., Inc., New York 36, N. Y. (A, H, I, K, S, T, V)
Danberg Chemical Co., Wallingford, Conn. (A, I, K)
★Diamond Alkali Co., Cleveland 14, Ohio (F)
Eagle-Picher Co., The, Cincinnati 1, Ohio (J, R)
Electronic Mechanics, Inc., Clifton, N. J. (P)
★English Mica Co., The, Stamford, Conn. (P)
★Ferro Corp., Fiber Glass Div., Nashville 11, Tenn. (L)
Franklin Mineral Products, Co., Franklin, N. C. (P)
Garvin, P., Inc., Hartford, Conn. (C, K, L)
General Fibre Co., Inc., Walpole, Mass. (I, K, S)
★Georgia Kaolin Co., Elizabeth, N. J. (G)
Georgia Marble Co., The, Calcium Products Div., Tate, Ga. (D)
★Harwick Standard Chemical Co., Akron 5, Ohio (G, I, K, N, P, T)
Hastings Plastics, Inc., Santa Monica, Calif. (C, G, L, N, O, P, R, T)
Haveg Industries, Inc., Wilmington 8, Del. (C, M)
★Hayden Mica Co., Inc., Wilmington, Mass. (P)
Henley & Co., Inc., New York 17, N. Y. (R)
Huber, J. M., Corp., New York, N. Y. (G, E, R)
International Filler Corp., N. Tonawanda, N. Y. (A, I, K, V)
International Textile Co., Chicago 39, Ill. (I, K, L, S)
★Johns-Manville, New York 16, N. Y. (C, J, L)
Lignum Chemical Works, The, Long Island City 1, N. Y. (V)
Miller, Frank, & Sons, Chicago 36, Ill. (S, V)
★Minerals & Chemicals Corp. of America, Menlo Park, N. J. (B, G)
★Modiglass Fibers, Inc., Bremen, Ohio (L)
Moretti-Harrah Marble Co., Sylacauga, Ala. (D)
Mundane Co., The, Verplanck, N. Y. (A, I, S)
★Mycalex Corp. of America, Clifton, N. J. (P)
National Gypsum Co., Buffalo 2, N. Y. (D)
New England Lime Co., Adams, Mass. (D)
North American Asbestos Corp., Chicago 8, Ill. (C)
Ohio Lime Co., Woodville, Ohio (D)
★Omni Products Corp., New York 16, N. Y. (L)
Owens-Corning Fiberglas Corp., New York 2, N. Y. (L)
Pelmor Laboratories, Inc., Newtown, Pa. (R)
Philadelphia Quartz Co., Philadelphia 6, Pa. (R)
★Pittsburgh Plate Glass Co., Fiber Glass Div., Pittsburgh 22, Pa. (L)
Plastics Materials Corp., South Windham, Maine (V)
Plymouth Cordage Co., Plymouth, Mass. (S)
★Plymouth Fibres, Brooklyn 1, N. Y. (I, K)
Plymouth Industrial Products, Inc., Sheboygan, Wis. (C)
★Powhatan Mining Co., Baltimore 7, Md. (C)
Quaker Oats Co., The, Chemicals Div., Chicago 54, Ill. (N)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (C)
Rayon Processing Co. of R. I., Pawtucket, R. I. (I, K, L, O, Q, S)
Ren Plastics, Inc., Lansing 9, Mich. (I)
Southern Clays, Inc., New York 6, N. Y. (G)
★Standard-Union Fibre Co., Philadelphia 34, Pa. (I, K, S)
Stein, Hall & Co., Inc., New York 17, N. Y. (S)
Summit Mining Corp., Carlisle, Pa. (B, P)
Technicraft Co., Boston 34, Mass. (R)
Tennessee Products & Chemical Corp., Nashville, Tenn. (R)
Thompson, Weinman & Co., New York 17, N. Y. (D)
U. S. Glass Fibre Co., Manchester, Conn. (L)
★United Carbon Co., Inc., Charleston 27, W. Va. (E)
Victorville Lime Rock Co., Sub. of C. K. Williams & Co., Victorville, Calif. (D)
White Pigments Corp., W. Rutland, Vt. (D)
★Whittaker, Clark & Daniels, Inc., New York 7, N. Y. (C, F, G, J, M, P, R, T)
★Wilner Wood Refinery, Norway, Maine (V)
★Witco Chemical Co., Inc., New York 17, N. Y. (E)
Wood Flour, Inc., Winchester, N. H. (V)

PAPER FOR RESIN IMPREGNATION

A. Decorative Laminates
B. Industrial Laminates

Brown Co., Boston 14, Mass. (A)
Decotone Products Div., Fitchburg Paper Co., Fitchburg, Mass. (A, B)
Fiberform, Inc., Oconomowoc, Wis. (A)
★Hurlbut Paper Co., South Lee, Mass. (A, B)
★Johns-Manville, New York 16, N. Y. (B)
★Mosinee Paper Mills Co., Mosinee, Wis. (B)

★ Indicates Advertiser

North American Asbestos Corp., Chicago 8, Ill. (A, B)
★Omni Products Corp., New York 16, N. Y. (A, B)
Paper Products Development, New York 11, N. Y. (A, B)
Paterson Parchment Paper Co., Bristol, Pa. (A, B)
Printon Corp., New York, N. Y. (A, B)
★Riegel Paper Corp., New York 17, N. Y. (A, B)
★Sandman, Eli, Co., Worcester 9, Mass. (A, B)
Southern Chemical Cotton Co., Chattanooga 5, Tenn. (A, B)
★Wrenn Paper Co., The, Middletown, Ohio (A, B)

PAPER, PRE-IMPREGNATED FOR LAMINATING

Barr Corp., The, Richmond Hill, N. Y.
BoMyte Co., The, Silverdale, Pa.
★Coast Mfg. & Supply Co., Livermore, Calif.
Chemtron Fiber Glass Co., El Monte, Calif.
Cromwell Paper Co., Chicago 1, Ill.
★Decar Plastic Corporation, Middleton, Wis.
Dewey & Almy Chemical Co. Div., W. R. Grace & Co., Cambridge 40, Mass.
Electro-Technical Products Div., Sun Chemical Corp., Nutley 10, N. J.
Endura Corp., Quakertown, Pa.
Fiberfoam, Inc., Oconomowoc, Wis.
Kimberly-Clark Corp., Neenah, Wis.
Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn.
★New England Laminates Co. Inc., Stamford, Conn.
★Omni Products Corp., New York 16, N. Y.
Polyplastex United, Inc., Union, N. J.
Printon Corp., New York 10, N. Y.
Rainier Plywood Co., Tacoma, Wash.
★Riegel Paper Corp., New York 17, N. Y.
Rogers Corp., Rogers, Conn.
★Sandman, Eli, Co., Worcester 9, Mass.
★Standard Insulation Co., Inc., E. Rutherford, N. J.
Taylor Fibre Co., Norristown, Pa.
★U. S. Polymeric Chemicals, Inc., Stamford, Conn.

PAPER, PRINTED FOR LAMINATING

Aacon Industries, Inc., Brooklyn, N. Y.
Decotone Products Div., Fitchburg Paper Co., Fitchburg, Mass.
★Morart Gravure Corp., Holyoke, Mass.
Paper Products Development, New York, N. Y.
Paterson Parchment Paper Co., Bristol, Pa.
Printon Corp., New York, N. Y.
★Riegel Paper Corp., New York 17, N. Y.

Laminates and Reinforced Plastics

For list of distributors, see p. 1161

CORES FOR SANDWICH CONSTRUCTION

A. Balsa Wood
B. Foamed Plastics
C. Honeycomb

American Latex Products Corp., Hawthorne, Calif. (B)
Armstrong Cork Co., Lancaster, Pa. (B)
B. B. Chemical Co., Cambridge 39, Mass. (B)
Balsa Ecuador Lumber Corp., New York 36, N. Y. (A)
★Brunswick-Balke-Collender Co., Defense Products Div., Muskegon, Mich. (B, C)
Buckstaff Co., The, Oshkosh, Wis. (C)
Calumet Fiberglass Products Co., Hammond, Ind. (A, C)
Carwin Co., The, North Haven, Conn. (B)
Chemold Co., Santa Monica, Calif. (A, B)
Chemtron Fiber Glass Co., El Monte, Calif. (A, B, C)
Continental Can Co., Inc., Conolite Dept., Wilmington 99, Del. (C)
★Dayton Rubber Co., The, Dayton, Ohio (B)
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas (B)
★Douglas Aircraft Co., Inc., Santa Monica, Calif. (C)
★Dow Chemical Co., The, Midland, Mich. (B)
Emerson & Cuming, Inc., Canton Mass. (B)
Englander Co., Inc., The, Industrial Plastics Div., Baltimore 23, Md. (B, C)
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio (C)
General Tire & Rubber Co., The, Marion, Ind. (B)
★Glo-Brite Foam Plastic Products, Chicago 45, Ill. (B)
Hastings Plastics, Inc., Santa Monica, Calif. (B)

★ Indicates Advertiser

Hexcel Products Inc., Berkeley 10, Calif. (C)
International Balsa Corp., Jersey City 4, N. J. (A)
★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (B)
Liss Products, Inc., Grasmore, N. H. (A)
Microcell, Ltd., London W.C. 2, England (C)
Modular Molding Corp., Burlington, N. J. (B, C)
Newport Plastics Corp., Newport, Vt. (A, B)
★Nopco Chemical Co., N. Arlington, N. J. (B)
Plastex Laminates, Inc., Hialeah, Fla. (C)
Polyply Co., San Diego 9, Calif. (C)
Rainier Plywood Co., Tacoma, Wash. (B)
★Reichhold Chemicals, Inc., White Plains, N. Y. (B)
Shamban & Co., W. S., Culver City, Calif. (B)
Southwestern Plastics, Inc., Houston 36, Texas (B)
Summit Industries, Inc., Gardena, Calif. (A, B, C)
Thompson Fiber Glass, H. I., Los Angeles 7, Calif. (C)
United Progress, Inc., Albany 5, N. Y. (B)
Universal Moulded Products Corp., Bristol, Va. (B, C)
Urethane Corp. of America, Medina, N. Y. (B)
Valco Corp., St. Paul, Minn. (A, B, C)
Victory Plastics Co., Hudson, Mass. (B)
Westinghouse Electric Corp., Micarta Div., Hampton, S. C. (C)
Young Development Div., Explosives Dept., Hercules Powder Co., Inc., Rocky Hill, N. J. (C)

HARDBOARD

Buckstaff Co., The, Oshkosh, Wis.
★Detroit Macoid Corp., Detroit 4, Mich.
Masonite Corp., Chicago 2, Ill.
Microcell, Ltd., London W.C. 2, England
★United States Gypsum Co., Chicago 6, Ill.
Universal Moulded Products Corp., Bristol, Va.
Woodall Industries, Inc., Detroit 34, Mich.

LAMINATES

A. Decorative, High-Pressure
B. Industrial, High-Pressure

Acme Laminating & Plastics Co., Inc., Detroit, Mich. (A)
Allegheny Plastics, Inc., Coraopolis, Pa. (A, B)
All-Tech Industries, Inc., Miami 68, Fla. (A)
★Anchor Plastics Co., Inc., Long Island City 6, N. Y. (A)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Cleveland 6, Ohio (A, B)
Avery Label Co., Monrovia, Calif. (A)
★Blank, Arthur, & Co., Inc., Boston 15, Mass. (A, B)
BoMyte Co., The, Silverdale, Pa. (A, B)
Buckstaff Co., The, Oshkosh, Wis. (A)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (B)
Calfibe Co., Redlands, Calif. (A, B)
Chemold Co., Santa Monica, Calif. (A, B)
★Clifton Hydraulic Press Co., Clifton, N. J. (A, B)
Coating Products, Inc., Englewood, N. J. (A)
Colorvision Plastics, Inc., Boston 16, Mass. (A)
★Commercial Plastics & Supply Corp., New York 12, N. Y. (B)
Consolidated Plastic Sales Co., St. Louis 23, Mo.
Consoweld Corp., Wisconsin Rapids, Wis. (A, B)
Continental Can Co., Inc., Conolite Dept., Wilmington 99, Del. (A, B)
★Continental-Diamond Fibre Corp., Sub. of Budd Co., Newark, Del. (B)
Crowl, Charles, Co., El Monte, Calif. (A, B)
Curry Arts, Scranton 9, Pa. (A, B)
★Decar Plastic Corp., Middleton, Wis. (A)
★Detroit Macoid Corp., Detroit, Mich. (B)

- ★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany (A, B)
- Efka Plastic Corp., Hoboken, N. J. (A)
- ★Emeloid Co., Inc., The, Hillside 5, N. J. (A, B)
- ★Engineered Plastics, Inc., Gibsonville, N. C. (B)
- Englander Co., Inc., The, Industrial Plastics Div., Baltimore 23, Md. (B)
- Farley & Loetscher Mfg. Co., Plastics Div., Dubuque, Iowa (A, B)
- Fasson Products, Painesville, Ohio (A)
- Fersons Industries, Inc., New York 1, N. Y. (A, B)
- Fiberesin Plastics Co., Oconomowoc, Wis. (A, B)
- Fiber Glass Plastic, Inc., Miami 47, Fla. (A, B)
- Firmaline Products, Inc., Midland Park, N. J. (B)
- ★Formica Corp., The, Cincinnati 32, Ohio (A, B)
- Fortin Plastics, Van Nuys, Calif. (B)
- Franklin Fibre-Lamitex Corp., Wilmington 99, Del. (B)
- General Electric Co., Laminated Products Dept., Coshocton, Ohio (A, B)
- General Plastics Corp., Paterson, N. J. (B)
- Gisholt Machine Co., Madison 4, Wis. (A, B)
- Hanley Plastics Co., St. Louis 17, Mo. (A, B)
- Haveg Industries, Inc., Wilmington 8, Del. (B)
- Hawley Products Co., St. Charles, Ill. (A)
- Hays Mfg. Co., Erie Pa. (B)
- Joclin Mfg. Co., Wallingford, Conn. (B)
- ★Johns-Manville, New York, N. Y. (B)
- Kaumagraph Co., Wilmington 99, Del. (A)
- Lamex, Inc., Norcross, Ga. (B)
- Laminated Fiberglass Corp. of America, New York 5, N. Y. (A, B)
- Lewis, J. P., Co., The, Plastic Products Div., Beaver Falls, N. Y. (B)
- Lone Star Plastics Co., Inc., Fort Worth, Texas (B)
- Lumar Optical Mfg. Co., Inc., Mt. Vernon, N. Y. (A, B)
- Malco Plastics, Inc., Baltimore 15, Md. (A, B)
- Mica Insulator, Div. of Minnesota Mining & Mfg. Co., Schenectady N. Y. (A B)
- ★Mico Instrument Co., Cambridge 38, Mass. (A, B)
- Microcell, Ltd., London W.C. 2, England (A, B)
- Molded Fiber Glass Co., Ashtabula, Ohio (B)
- Molded Fiber Glass Tray Co., Linesville, Pa. (B)
- ★National Plastic Products Co., The, Odenton, Md. (A)
- National Vulcanized Fibre Co., Wilmington 99, Del. (B)
- ★New England Laminates Co., Inc., Stamford, Conn. (B)
- Newport Plastics, Newport, Vt. (B)
- Northern Plastics Corp., La Crosse, Wis. (B)
- Numa Plastics Corp., New York 22, N. Y. (A)
- Parkwood Laminates, Inc., Wakefield, Mass. (A, B)
- Plastex Laminates, Hialeah, Fla. (A)
- Plastic Laminating Corp., Vauxhall, N. J. (A)
- Plastic Service Corp., New York 10, N. Y. (A, B)
- Plastics by Chapman, Richmond, Calif. (A)
- Plastics Industries, Inc., Athens, Tenn. (A)
- Polyplastex United, Inc., Union, N. J. (A, B)
- Polyply Co., San Diego 9, Calif. (A, B)
- Printon Corp., New York 10, N. Y. (A, B)
- Rayll Plastics Co., Brooklyn, N. Y. (A)
- Reiss Associates, Lowell, Mass. (A)
- Reynolds Plastics, Inc., Walled Lake, Mich. (A, B)
- Richardson Co., The, Melrose Park, Ill. (B)
- Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y. (A)
- St. Regis Paper Co., Panelyte Div., Kalamazoo, Mich. (A)
- ★Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio (B)
- Shamban, W. S., & Co., Culver City, Calif. (B)
- Spaulding Fibre Co., Inc., Tonawanda, N. Y. (B)
- Standard Pyroxoloid Corp, Leominster, Mass. (A)
- Summit Industries, Inc., Gardena, Calif. (B)
- ★Swedlow, Inc., Los Angeles, Calif. (A, B)
- Synthane Corp., Oaks, Pa. (B)
- Taylor Fibre Co., Morristown, Pa. (B)
- Thompson, H. I., Fiber Glass, Los Angeles 7, Calif. (B)
- Valco Corp., St. Paul 4, Minn. (B)
- Victory Plastics Co., Hudson, Mass. (A, B)
- Westinghouse Electric Corp., Micarta Div., Hampton, S. C. (A, B)
- Willson Camera Co., Havertown, Pa. (A, B)
- Woodall Industries, Inc., Detroit 34, Mich. (A)

LAMINATED RODS AND TUBES

- Airconductors, Gardena, Calif.
- Apex Reinforced Plastics Div., White Sewing Machine Corp., Cleveland 6, Ohio
- Brilhart Plastics Corp., Mineola, N. Y.
- ★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
- Chemtron Fiber Glass Co., El Monte, Calif.
- ★Colonial Kolonite Co., Chicago, Ill.
- Columbia Products Co., Columbia, S. C.
- ★Commercial Plastics & Supply Corp., New York 12, N. Y.
- ★Continental-Diamond Fibre Corp., Sub. of The Budd Co., Newark, Del.
- ★Dumont Corp., San Rafael, Calif.
- Du Verre, Inc., Arcade, N. Y.
- ★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany
- Emerson Plastics Corp., Bronx 61, N. Y.
- ★Engineered Plastics, Inc., Gibsonville, N. C.
- ★Formica Corp., The, Cincinnati 32, Ohio
- Fortin Plastics, Inc., Van Nuys, Calif.
- Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
- General Electric Co., Laminated Products Dept., Coshocton, Ohio
- Glasply Corp., Mt. Vernon, N. Y.
- Harstil Industries Co., St. Clair Shores, Mich.
- Leon Chemical Industries, Inc., Warren, Mich.
- Magnolia Plastics, Inc., Chamblee, Ga.
- Mica Insulator, Div. of Minnesota Mining & Mfg. Co., Schenectady, N. Y.
- Microcell, Ltd., London W.C. 2, England
- National Vulcanized Fibre Co., Wilmington 99, Del.
- Pacific Plastics Co., Inc., Seattle, Wash.
- ★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa.
- Ren Plastics, Inc., Lansing 9, Mich.
- Resistoflex Corp., Roseland, N. J.
- Richardson Co., The, Melrose Park, Ill.
- Schori Process Corp., Long Island City 1, N. Y.
- Silicone Insulation, Inc., Bronx 61, N. Y.
- Spaulding Fibre Co., Inc., Tonawanda, N. Y.
- Specht Plastics, Inc., Somerset, Pa.
- Summit Industries, Inc., Gardena, Calif.
- Taylor Fibre Co., Norristown, Pa.
- Universal Moulded Products Corp., Bristol, Va.
- Valco Corp., St. Paul 4, Minn.

PRE-IMPREGNATED MATERIALS

(See Fibrous Glass and Paper, p. 1108)

PREMIX

A. Epoxy B. Phenolic C. Polyester

- ★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (C)
- ★American Cyanamid Co., Plastics and dom, Pa. (C)
- Baird Dynamic Corp., Stratford, Conn. (C)
- Biggs, Carl H., Co., Inc., Santa Monica, Calif. (A)
- Blum, Paul, Co., Buffalo 10, N. Y. (B)
- Brilhart Plastics Corp., Mineola, N. Y. (A, C)
- ★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (C)
- Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif. (A, C)
- Chemold Co., Santa Monica, Calif. (C)
- Chemtron Fiber Glass Co., El Monte, Calif. (A, C)
- ★Clinton Co., The, Chicago 22, Ill. (A)
- ★Colonial Kolonite Co., Chicago 47, Ill. (A, B, C)
- ★Dayton Rubber Co., The, Dayton, Ohio (C)
- Firmaline Products, Inc., Midland Park, N. J. (C)
- Fortin Plastics, Inc., Van Nuys, Calif. (A, C)
- ★Furane Plastics, Inc., Los Angeles 39, Calif. (A)
- General Plastics Corp., Los Angeles 64, Calif. (C)
- Gisholt Machine Co., Madison 4, Wis. (A, B, C)
- Glastic Corp., The, Cleveland 21, Ohio (C)
- Hays Mfg. Co., Erie, Pa. (C)
- Houghton Laboratories, Inc., Olean, N. Y. (A)
- Kish Industries, Inc., Lansing 6, Mich. (A, B, C)
- Laminated Fiberglass Corp. of America, New York 5, N. Y. (C)
- Lewis, G. B., Co., Watertown, Wis. (C)
- Magnolia Plastics, Inc., Chamblee, Ga. (A, C)
- Modular Molding Corp., Burlington, N. J. (C)
- Molded Fiber Glass Co., Ashtabula, Ohio (C)
- Molded Fiber Glass Tray Co., Linesville, Pa. (C)
- Mold-Rite Plastics, Inc., Cambridge, Ohio (C)
- Molex Products Co., Brookfield, Ill. (C)
- National Vulcanized Fibre Co., Wilmington 99, Del. (C)
- Northern Plastics Corp., La Crosse, Wis. (A, B)
- Plastic Service Corp., New York 10, N. Y. (A, B, C)
- ★Plumb Chemical Corp., Philadelphia 37, Pa. (C)
- Reynolds Plastics, Inc., Walled Lake, Mich. (C)
- Schramm Fiberglass Products, Inc., Chicago 18, Ill. (A, C)

★ Indicates Advertiser

Spaulding Fibre Co., Inc., Tonawanda, N. Y. (A, B)
Universal Moulded Products Corp., Bristol, Va. (A, B, C)
Valco Corp., St. Paul 4, Minn. (A, B, C)
Woodall Industries, Inc., Detroit 34, Mich. (C)

REINFORCED MOLDING COMPOUNDS

A. Epoxy Base
B. Melamine Base
C. Phenolic Base
D. Polyester Base
E. Styrene Base

Aerojet-General Corp., Structural Plastics Div., Azusa, Calif. (A, C)
★American Cyanamid Co., Plastics and Resins Div., New York 20, N. Y. (B, D)
★American Insulator Corp., New Freedom, Pa. (A, D)
American Reinforced Plastics Co., Los Angeles 27, Calif. (C, D)
American Resin Corp., Chicago 13, Ill. (A, C, D)
Archer-Daniels-Midland Co., Minneapolis 2, Minn. (D)
Aries Laboratories, Inc., Long Island City, N. Y. (A)
Atlas Powder Co., Wilmington 99, Del. (D)
Baird Dynamic Corp., Stratford, Conn. (D)
Biggs, Carl H., Co., Inc., Santa Monica, Calif. (A)
Brilhart Plastics Corp., Mineola, N. Y. (A, D)
★Celanese Corp. of America, Plastics Div., Newark 2, N. J. (D)
Chemold Co., Santa Monica, Calif. (D)
Chemtron Fiber Glass Co., El Monte, Calif. (A, D)
★Clinton Co., The, Chicago 22, Ill. (A)
★Coast Mfg. & Supply Co., Livermore, Calif. (A, C, D)
★Colonial Kolonite Co., Chicago 47, Ill. (A)
Cordo Chemical Corp., Norwalk, Conn. (A, B, C, D)
Crowl, Charles, Co., El Monte, Calif. (A)
★Dayton Rubber Co., The, Dayton, Ohio (D)
★Durez Plastics Div., Hooker Chemical Corp., N. Tonawanda, N. Y. (C)
Emerson & Cuming, Inc., Canton, Mass. (A)
★Fiberfil, Inc., Warsaw, Ind. (E)
★Furane Plastics, Inc., Los Angeles 39, Calif. (A)
Gisholt Machine Co., Madison 4, Wis. (A, B, C, D)
Glastic Corp., The, Cleveland, Ohio (D)
Hays Mfg. Co., Erie, Pa. (D)
Houghton Laboratories, Inc., Olean, N. Y. (A)
Kaumagraph Co., Wilmington, Del. (B)
Laminated Fiberglass Corp. of America, New York 5, N. Y. (D)
Leon Chemical Industries, Inc., Warren, Mich. (A, D)
Lewis, G. B., Co., Watertown, Wis. (D)
Lone Star Boat Co., Grand Prairie, Texas (D)
Magnolia Plastics, Inc., Chamblee, Ga. (A, C, D)
Melamine Plastics, Inc., Winona, Minn. (B)
Mesa Plastics Co., Los Angeles 25, Calif. (D)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., St. Paul 6, Minn. (A, C)
Modular Molding Corp., Burlington, N. J. (D)
Mold-Rite Plastics, Inc., Cambridge, Ohio (D)
Molex Products Co., Brookfield, Ill. (D)
National Vulcanized Fibre Co., Wilmington 99, Del. (D)
Newport Plastics Corp., Newport, Vt. (A, D)
Northern Plastics Corp., La Crosse, Wis. (A, B, C)
★Plumb Chemical Corp., Philadelphia 37, Pa. (D)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (A, C, D)
★Reichhold Chemicals, Inc., White Plains, N. Y. (A, C, D)
Rogers Corp., Rogers, Conn. (C)
Schramm Fiberglass Products, Inc., Chicago 18, Ill. (A, D)
★U. S. Polymeric Chemicals, Inc., Stamford, Conn. (A, C, D)
Universal Moulded Products Corp., Bristol, Va. (A, B, C, D, E)
Valco Corp., St. Paul 4, Minn. (A, B, C, D)
Westinghouse Electric Corp., Micarta Div., Hampton, S. C. (A, C, D)
Woodall Industries, Inc., Detroit 34, Mich. (D)

VULCANIZED FIBRE

★Continental-Diamond Fibre Corp., Sub. of The Budd Co., Newark, Del.
★Dynamit-Actien-Gesellschaft (vormals Alfred Nobel & Co.), Troisdorf/Köln, West Germany
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
National Vulcanized Fibre Co., Wilmington 99, Del.
Spaulding Fibre Co., Inc., Tonawanda, N. Y.
Taylor Fibre Co., Morristown, Pa.

Machinery and Equipment

For list of distributors, see p. 1162

ABRASIVE FORMING MACHINES

Bliss, E. W., Co., Canton 10, Ohio
★Engineering Laboratories, Inc., Pompton Lakes, N. J.
★Erie Foundry Co., Erie, Pa.
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
Telemat Corp., Worcester 3, Mass.
White, S. S., Dental Mfg. Co., Industrial Div., New York 16, N. Y.

ACCUMULATORS

A. Air Ballasted
B. Hydropneumatic
C. Weight

★Adamson United Co., Akron 4, Ohio (A, B, C)
Airmatic Valve, Inc., Cleveland 9, Ohio (B)
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England (B)
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa. (B)
Blaw-Knox Co., Pittsburgh 22, Pa. (A, B)
Bradley & Turton, Ltd., Kidderminster, England (C)
★Dunning & Boschert Press Co., Inc., The, Syracuse, N. Y. (C)
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio (A, C)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (B, C)
★French Oil Mill Machinery Co., The, Piqua, Ohio (B, C)
Greer Hydraulics, Inc., Jamaica 30, N. Y. (B)
★Karlton Machinery Corp., Chicago 11, Ill. (A, B)
Lake Erie Machinery Corp., Buffalo 17, N. Y. (A, B, C)
Lembo Machine Works, Inc., Paterson 4, N. J. (C)
Machine Factory & Foundry Ltd., Netstal, Switzerland (A, B)
★Miller Fluid Power Div., Flick-Reedy Corp., Bensenville, Ill. (B)
Mount Hope Machinery Co., Taunton, Mass. (C)
★Shaw, Francis, & Co., Ltd., Manchester 11, England (C)
Siempelkamp, G., & Co., Krefeld, Germany (A, B)
★Symons, Ralph B., Associates, Inc., Tiverton, R. I. (A)
★Waldron, John, Corp., New Brunswick, N. J. (A, B, C)
★Watson-Stillman Press Div., Farrel-Birmingham Co., Inc., Rochester 10, N. Y. (A, B, C)
★Werner & Pfleiderer, Stuttgart, Germany (A, B)
★Wood, R. D., Co., Philadelphia 5, Pa. (B, C)

AIR COMPRESSORS

(Air Presses)

Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
★Binks Mfg. Co., Chicago 12, Ill.
Blaw-Knox Co., Pittsburgh 22, Pa.
★Callanan, J. A., Co., Chicago 6, Ill.
DeVilbiss Co., The, Toledo 1, Ohio
Electric Trading Co., New York, N. Y.
★Famco Machine Co., Kenosha, Wis.
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill.
★Lawton, C. A., Co., The, DePere, Wis.
Leiman Bros., Inc., Newark 1, N. J.
Lincoln Engineering Co., St. Louis 20, Mo.
★Mico Instrument Co., Cambridge 38, Mass.

★ Indicates Advertiser

Nash Engineering Co., The, S. Norwalk, Conn.
Pennsylvania Pump & Compressor Co., Easton, Pa.
Quincy Compressor Co., Quincy, Ill.
★Rainville Co., Inc., The, Garden City, N. Y.
Worthington Corp., Harrison, N. J.

ARBOR PRESSES

★Acromark Co., The, Elizabeth 4, N. J.
Albert, P. E., & Son, Trenton 5, N. J.
Bellows Co., The, Akron 9, Ohio
★Dake Corporation, Grand Haven, Mich.
★Dunning & Boschert Press Co., Inc., The, Syracuse, N. Y.
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio
★Famco Machine Co., Kenosha, Wis.
Greenerd Arbor Press Co., Nashua, N. H.
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill.
★Lawton, C. A., Co., The, DePere, Wis.
Machine Factory & Foundry Ltd., Netstal, Switzerland
★Watson-Stillman Press Div., Farrel-Birmingham Co., Inc., Rochester 10, N. Y.

AUTOCLAVES

★Adamson United Co., Akron 4, Ohio
Artisan Metal Products, Inc., Waltham 54, Mass.
★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany
Blaw-Knox Co., Pittsburgh 22, Pa.
★Blue, E. B., Co., S. Norwalk, Conn.
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio
Buss, Ltd., Basel, Switzerland
Continental Machinery Co., Inc., New York 7, N. Y.
Devine, J. P., Mfg. Co., Pittsburgh 1, Pa.
First Machinery Corp., Brooklyn, N. Y.
General Engineering Co., Radcliffe, Lancs., England
★Hull Corp., Hatboro, Pa.
Iddon Brothers Ltd., Leyland, Lancashire, England
Patterson Foundry and Machine Co., The, E. Liverpool, Ohio
Seal Cast Co., Inc., Philadelphia 25, Pa.
Tower Iron Works, Inc., Providence, 1, R. I.

BALING MACHINES

★Consolidated Baling Machine Co., Brooklyn 15, N. Y.
Galland-Henning Mfg. Co., Milwaukee 46, Wis.
Goldberg & O'Brien Electric Co., Chicago 6, Ill.
Industrial Vibrator & Machinery Co., San Francisco, Calif.
Lake Engineering Sales Co., Hammond, Ind.
Loeser, E. W., Co., Buffalo 11, N. Y.
Logemann Bros., Co., Milwaukee 45, Wis.
Lombard Corp., Youngstown 3, Ohio
Minnich Machine Works, Waynesboro, Pa.
Tonawanda Engineering Co., Tonawanda, N. Y.

BARRELS, TUMBLING

Abbe Engineering Co., New York 17, N. Y.
★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
Continental Machinery Co., Inc., New York 7, N. Y.
Crown Machinery, Inc., Los Angeles 11, Calif.
Ferry Machine Co., Kent, Ohio
★Injection Molders Supply Co., Cleveland 20, Ohio
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
Lord Chemical Corp., York, Pa.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Morse Mfg. Co., Inc., E. Syracuse, N. Y.
★Omni Products Corp., New York 16, N. Y.
Rampe Mfg. Co., Cleveland 10, Ohio
Ransohoff Co., Hamilton, Ohio
Siebert, R. R., Co., The, Rochester 4, N. Y.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.
Tower Iron Works, Inc., Providence, 1, R. I.
★Tumb-L-Matic, Inc., Stamford, Conn.

BLENDERS

Abbe Engineering Co., New York 17, N. Y.
★Abbé, Paul O., Inc., Little Falls, N. J.
★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
Blaw-Knox, Pittsburgh 22, Pa.
★Bonnot Co., The, Canton 2, Ohio
Colton, Arthur, Co., Div. of Snyder Corp., Detroit 7, Mich.
Crown Machinery, Inc., Los Angeles 11, Calif.
Day, J. H., Co., The, Cincinnati 12, Ohio
Devine, J. P., Mfg. Co., Pittsburgh 1, Pa.
★Entoleter Div., Safety Industries, Inc., New Haven, Conn.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
Ferro Corp., Patterson Equipment Div., East Liverpool, Ohio
First Machinery Corp., Brooklyn 15, N. Y.
Industrial Plastics, Ltd., London WI, England
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Manton-Gaulin Mfg. Co., Inc., Everett 49, Mass.
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
Munson Mill Machinery Co., Utica 1, N. Y.
Patterson Foundry and Machine Co., The, E. Liverpool, Ohio
Patterson-Kelley Co. Inc., The, E. Stroudsburg, Pa.
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
★Prodex Corp., Fords, N. J.
Rainco Mfg., Inc., Franklin, Pa.
★Rainville Co., Inc., The, Garden City, N. Y.
Read Standard, Div. of Capitol Products Corp., York, Pa.
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.
Ross, Charles, & Son Co., Brooklyn 5, N. Y.
Sprout, Waldron & Co., Inc., Muncy, Pa.
Sturtevant Mill Co., Boston 22, Mass.
Tower Iron Works, Inc., Providence 1, R. I.
★Werner & Pfleiderer, Stuttgart, Germany
Young Machinery Co., The, Inc., Muncy, Pa.

BLOW MOLDING MACHINES

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
Air-Formed Products Corp., Nashua, N. H.
★Auto-Blow Corp., Sub. of National Cleveland Corp., Bridgeport 10, Conn.
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany
Blow-O-Matic Corp., The, Bridgeport 7, Conn.
★Boston Plastic Machinery, Inc., Boston 10, Mass.
★Covema s.r.l., Milan, Italy
★Daniels, T. H. & J., Ltd., Stroud, Gloucestershire, England
Eisler Engineering Co., Inc., Newark 3, N. J.
★Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany
★Goulding Mfg. Co., Saginaw, Mich.
Industrial Plastics Ltd., London WI, England
★Kato Seishakusho Co., Ltd., Tokyo, Japan
★Kautex-Werk Reinold Hagen, Hangelar uber Siegburg, West Germany
Machine Factory & Foundry Ltd., Netstal, Switzerland
★Mahl Industries, Inc., New York 56, N. Y.
★Moslo Machinery Co., Cleveland 15, Ohio
★Negri Bossi & Co., Milan, Italy
★Prodex Corp., Fords, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.

BOILERS

★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany
Buss, Ltd., Basel, Switzerland
Cyclotherm Div., National-U. S. Radiator Corp., Oswego, N. Y.
Eclipse Fuel Engineering Co., Rockford, Ill.
First Machinery Corp., Brooklyn 15, N. Y.
Mears-Kane-Ofeldt, Inc., Bridgeport, Pa.
★Pantex Mfg. Corp., Pawtucket, R. I.
★Rainville Co., Inc., The, Garden City, N. Y.

CAKING PRESSES

Albert, P. E., & Son, Trenton 5, N. J.
★Bonnot Co., The, Canton 2, Ohio
★French Oil Mill Machinery Co., The, Piqua, Ohio
★Lawton, C. A., Co., The, DePere, Wis.
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
G. Siempelkamp & Co., Krefeld, Germany
★Werner & Pfleiderer, Stuttgart, Germany

CALENDERS

★Adamson United Co., Akron 4, Ohio
★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio
Continental Machinery Co., Inc., New York 7, N. Y.
Custom Machine & Design, Inc., Akron 9, Ohio
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
First Machinery Corp., Brooklyn 15, N. Y.
Iddon Brothers Ltd., Leyland, Lancashire, England
★J M C Co., Newark 5, N. J.
★Johnson Machinery Co., Newark 5, N. J.

★ Indicates Advertiser

★Klienewefers, Joh., Söhne, Krefeld, West Germany
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.
Ross, Charles, & Son Co., Brooklyn 5, N. Y.
★Shaw, Francis, & Co., Ltd., Manchester 11, England
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass.
★Thropp, Wm. R., & Sons, Div. of J. M. Lehmann Co., Inc., Lyndhurst, N. J.
Toko Machine Industry Co., Ltd., Tokyo, Japan
Troester, Paul, Maschinenfabrik, Hannover-Wulfel, West Germany
Verduin, John, Machine Corp., Paterson 4, N. J.

CALENDERING EQUIPMENT

★Adamson United Co., Akron 4, Ohio
Albert, P. E., & Son, Trenton 5, N. J.
★Black-Clawson, Co., The, Dilts Div., Fulton, N. Y.
Continental Machinery Co., Inc., New York 7, N. Y.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
Iddon Brothers Ltd., Leyland, Lancashire, England
★Johnson Machinery Co., Newark 5, N. J.
★Kleinewefers, Joh., Söhne,, Krefeld, West Germany
★Liberty Machine Co., Inc., Paterson 4, N. J.
Mount Hope Machinery Co., Taunton, Mass.
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.
★Roehlen Engraving Works, Rochester 5, N. Y.
Ross, Charles, & Son Co., Brooklyn 5, N. Y.
★Shaw, Francis, & Co., Ltd., Manchester 11, England
Troester, Paul, Maschinenfabrik, Hannover-Wulfel, West Germany
Verduin, John, Machine Corp., Paterson 4, N. J.
★Waldron, John, Corp.; New Brunswick, N. J.

COATING MACHINES

(See also Wire Coating Machines)

A. Air Knife Coating
B. Dip Coating
C. Flame Spraying
D. Roller Coating

Abbott Plastic Machine Corp., Chicago 26, Ill. (D)
★Apex Machine Co., College Point 56, N. Y. (B, D)
Bischoff Chemical Corp., Ivoryton, Conn. (B)
★Black-Clawson Co., The, Dilts Div., Fulton, N. Y. (A, B, D)
★Blue, E. B., Co., S. Norwalk, Conn. (B)
★Conforming Matrix Corp., Toledo 2, Ohio (D)
Continental Machinery Co., Inc., New York 7, N. Y. (A, B, D)
Cooper, D. C., Co., Chicago 5, Ill. (B)
DeVilbiss Co., The, Toledo 1, Ohio (B)
Dornbusch & Co., Krefeld, West Germany (B, D)
Drying Systems Co., Chicago 40, Ill. (B, D)
★Dusenbery, John, Co., Verona, N. J. (D)
★Egan, Frank W., & Co., Somerville, N. J. (A, D)
★Faeco Machine Co., Inc., Paterson, N. J. (A, B, D)
★Finish Engineering Co., Inc., Erie, Pa. (D)
★Hofmann & Schwabe K. G., Krefeld, West Germany (A, B, D)
Hunt, Rodney, Machine Co., Orange, Mass. (D)
★Industrial Ovens, Inc., Cleveland 11, Ohio (B, D)
Inta Roto Machine Co., Richmond 3, Va. (D)
★Johnson Machinery Co., Newark 5, N. J. (D)
Ketchpel Engineering Co., West Englewood, N. J. (D)
★Liberty Machine Co., Inc., Paterson 4, N. J. (D)
★Litzler, C. A., Co., Inc., Cleveland 9, Ohio (A, B, D)
Monkley Corp., Worcester 8, Mass. (A, B, D)
★Polymer Processes, Inc., Reading, Pa. (B)
Randall Mfg. Co., Inc., New York 59, N. Y. (B)
Rotobond Co., Bound Brook, N. J. (D)
Rutherford Machinery Co., Div. of Sun Chemical Corp., East Rutherford, N. J. (D)
Schori Process Corp., Long Island City 1, N. Y. (C)
Shannon, Alexander J., Co., The, New York 38, N. Y. (B, D)
★Shaw, Francis, & Co., Ltd., Manchester 11, England (A, B)
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass. (A, B, D)
★Sta-Warm Electric Co., Ravenna, Ohio (B)
Toko Machine Industry Co., Ltd., Tokyo, Japan (A, B, C, D)
Union Tool Corp., The, Warsaw, Ind. (A, B, D)
Verduin, John, Machine Corp., Paterson 4, N. J. (B, D)
★Waldron, John, Corp., New Brunswick, N. J. (A, B, D)
Wallace, L. R., & Co., Pasadena 1, Calif. (D)
Web Controls Corp., W. Englewood, N. J. (D)
Weiss, Albert, & Co., Brooklyn 32, N. Y. (D)

COMPOUNDERS

(See Extruders, Mills, Intensive Mixers)

COMPRESSION PRESSES

A. Fully Automatic
B. Semi-Automatic
C. Hand-Operated

★Adamson United Co., Akron 4, Ohio (A, B, C)
Albert, P. E., & Son, Trenton 5, N. J. (A, B, C)
Atlas Hydraulics Div., Delaware Valley Mfg. Co., Inc., Philadelphia 34, Pa. (A, B, C)
Automold Co., Sub. of Wagner Bros., Inc., W. Los Angeles 64, Calif. (A, B, C)
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England (A, B)
Baker Bros., Toledo 10, Ohio (A)
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa. (A, B)
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany (A, B, C)
★Becker & Van Hüllen, Krefeld, West Germany (A, B, C)
Berthelsen Engineering, Joliet, Ill. (A, B)
★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany (A)
Birdsboro Steel Foundry Machine Co., Birdsboro, Pa. (B, C)
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio (B)
Bradley & Turton, Ltd., Kidderminster, England (B, C)
★Carver, Fred S., Inc., Summit, N. J. (C)
Clearing Div. of U.S. Industries, Inc., Chicago 38, Ill. (A, B)
★Clifton Hydraulic Press Co., Clifton, N. J. (A, B, C)
★Consolidated Baling Machine Co., Brooklyn 15, N. Y. (A, B, C)
★Covema s.r.l., Milan, Italy (A, B, C)
Custom Machine & Design, Inc., Akron 9, Ohio (A, B, C)
★Dake Corp., Grand Haven, Mich. (A, B, C)
★Daniels, T. H. & J., Ltd., Stroud, Gloucestershire, England (B, C)
★Davidson-Kennedy Co., Atlanta 18, Ga. (A, B, C)
★Dunning & Boschert Press Co., Inc., The, Syracuse, N. Y. (B, C)
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio (B, C)
★Erie Engine & Mfg. Co., Erie, Pa. (A, B, C)
★Erie Foundry Co., Erie, Pa. (A, B, C)
★Famco Machine Co., Kenosha, Wis. (A, B, C)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (B, C)
★Fjellman American, Inc., Joliet, Ill. (A)
★French Oil Mill Machinery Co., The, Piqua, Ohio (A, B, C)
General Engineering Co., Radcliffe, Lancs., England (B)
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill. (B, C)
★Hull-Standard Corp., Hatboro, Pa. (A, B, C)
★Hydraulic Press Mfg. Co., The, a Div. of Koehring Co., Mount Gilead, Ohio (A, B)
Iddon Brothers Ltd., Leyland, Lancashire, England (B, C)
★Improved Machinery, Inc., Nashua, N. H. (B)
Industrial Plastics, Ltd., London W.1, England (A)
★Johnson Machinery Co., Newark 5, N. J. (A, B, C)
★Karlton Machinery Corp., Chicago 11, Ill. (A, B, C)
Knuth Engineering, Chicago, Ill. (C)
Lake Erie Machinery Corp., Buffalo 17, N. Y. (A, B)
★Lawton, C. A., Co., The, DePere, Wis. (A, B, C)
Lempco Industrial, Inc., Bedford, Ohio (A, B, C)
Lodge & Shipley Co., The, Cincinnati 25, Ohio (B)
★Logan Hydraulics, Inc., Chicago 30, Ill. (B, C)
Loomis Engineering & Mfg. Co., Caldwell, N. J. (A, B, C)
★M & N Hydraulic Press Co., Inc., Clifton, N. J. (A, B, C)
Machine Factory & Foundry Ltd., Netstal, Switzerland (B, C)
★New England Butt Co., Providence, R. I. (A)
Oliver Corp., The, A. B. Farquhar Div., York, Pa. (A, B)
★Omni Products Corp., New York 16, N. Y. (A, B, C)
Pasadena Hydraulics, Inc., El Monte, Calif. (A, B, C)
Rodgers Hydraulic, Inc., Minneapolis 26, Minn. (A, B, C)
G. Siempelkamp & Co., Krefeld, Germany (A, B, C)
★Standard Tool Co., Leominster, Mass. (C)
★Stokes, F. J., Corp., Philadelphia 20, Pa. (A, B)
★Symons, Ralph B., Associates, Inc., Tiverton, R. I. (A, B, C)

★ Indicates Advertiser

★Triulzi, A. Off., s.a.s. Milan, Italy (A, B, C)
Verduin, John, Machine Corp., Paterson 4, N. J. (A, B)
Verson Allsteel Press Co., Chicago 19, Ill. (A, B)
Wabash Metal Products Co., Inc., Wabash, Ind. (B, C)
★Watson-Stillman Press Div., Farrel-Birmingham Co., Inc., Rochester 10, N. Y. (B)
★Werner & Pfleiderer, Stuttgart, Germany (A, B, C)
★Williams-White & Co., Moline, Ill. (B, C)
★Wood, R. D., Co., Philadelphia 5, Pa. (B, C)

CONTROLLERS

(See Instruments)

CONVEYORS

Abbott Plastic Machine Corp., Chicago 26, Ill.
★Blue, E. B., Co., S. Norwalk, Conn.
Carpco Mfg., Inc., Jacksonville 6, Fla.
Chain Belt Co., Milwaukee 1, Wis.
Cooper, D. C., Co., Chicago 5, Ill.
★Covema s.r.l., Milan, Italy
Day, J. H., Co., The, Cincinnati 12, Ohio
Dean Thermo-Panel Coil Div., Dean Products, Inc., Brooklyn 38, N. Y.
Dracco Div. of Fuller Co., Cleveland 5, Ohio
★Egan, Frank W., & Co., Somerville, N. J.
Emery, Vern, Co., Sun Valley, Calif.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
Ferry Machine Co., Kent, Ohio
Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
Herbert Products, Inc., Woodhaven 21, N. Y.
Indiana Commercial Filter Corp., Lebanon, Ind.
Industrial Plastics, Ltd., London W.1, England
Island Equipment Corp., Hialeah, Fla.
Jennings Engineering Co., Philadelphia 4, Pa.
★Karlton Machinery Corp., Chicago 11, Ill.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
L & P Tool Co., Cincinnati 25, Ohio
Lavorazione Materie Plastiche, S.A.S., Torino, Italy
Leon Machine & Engineering Co., Riverside, N. J.
Magnetic Engineering & Mfg. Co., Clifton, N. J.
Mercury Heat Sealing Equipment Co., Philadelphia 33, Pa.
Mercury Industries, Inc., Hillsdale, N. J.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
★Modern Plastic Machinery Corp., Lodi, N. J.
Motch & Merryweather Machinery Co., Cleveland 17, Ohio
★National Rubber Machinery Co., Akron 8, Ohio
Oliver Corp., The, A. B. Farquhar Div., York, Pa.
★Omni Products Corp., New York 16, N. Y.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
★Prodex Corp., Fords, N. J.
Pulverizing Machinery Div., Metals Disintegrating Co., Inc., Summit, N. J.
Read Standard, Div. of Capitol Products Corp., York, Pa.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
Robinson Air-Activated Conveyor Systems, New York 11, N. Y.
★Shaw, Francis, & Co., Ltd., Manchester 11, England
Spencer Turbine Co., Hartford 6, Conn.
Sprout, Waldron & Co., Inc., Muncy, Pa.
Standard Conveyor Co., North St. Paul 9, Minn.
★Sterling Extruder Corp., Linden, N. J.
Syntron Co., Homer City, Pa.
Tote System, Inc., Beatrice, Neb.
Union Tool Corp., The, Warsaw, Ind.
Verduin, John, Machine Corp., Paterson 4, N. J.
★Waldron, John, Corp., New Brunswick, N. J.
Wallace, L. R., & Co., Pasadena 1, Calif.
Whitaker, Douglas C., Glenside, Pa.
★Whitlock Associates, Inc., Oak Park 37, Mich.
Wilkinson Co., Akron 10, Ohio
Young Machinery Co., The, Inc., Muncy, Pa.

COOLING DEVICES

Al-Be Industries, South Gate, Calif.
Anson Tools & Gages, Inc., Erie, Pa.
Artisan Metal Products, Inc., Waltham 54, Mass.
Blaw-Knox Co., Pittsburgh 22, Pa.
Dean Thermo-Panel Coil Div., Dean Products, Inc., Brooklyn 38, N. Y.
★Egan, Frank W., & Co., Somerville, N. J.
Electric Trading Co., New York 13, N. Y.
General Engineering Co., Radcliffe, Lancs., England
Gerin Mfg. Co., Inc., Newark 7, N. J.
★Goulding Mfg. Co., Saginaw, Mich.
★Industrial Ovens Inc., Cleveland 11, Ohio
Industrial Plastics, Ltd., London W.1, England
★Injection Molders Supply Co., Cleveland 20, Ohio
J M C Co., Newark 5, N. J.
★Kleinewefers, Joh., Sohne, Krefeld, West Germany
L & P Tool Co., Cincinnati 25, Ohio
Lavorazione Materie Plastiche, S.A.S., Torino, Italy
Lembo Machine Works, Inc., Paterson 4, N.J.
★Liberty Machine Co., Inc., Paterson 4, N. J.
★Mayer Refrigerating Engineers, Lincoln Park, N. J.
Mercury Industries, Inc., Hillsdale, N. J.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.
★Modern Plastic Machinery Corp., Lodi, N. J.
Motch & Merryweather Machinery Co., Cleveland 17, Ohio
★National Rubber Machinery Co., Akron 8, Ohio
★Omni Products Corp., New York 16, N. Y.
★Pecorp, Inc., Wilmington 4, Del.
★Rainville Co., Inc., The, Garden City, N. Y.
★Saren, Inc., Chicago 51, Ill.
Shriver, T. & Co., Inc., Harrison, N. J.
★Sterling, Inc., Milwaukee 18, Wis.
Tenney Engineering, Inc., Union, N. J.
Verduin, John, Machine Corp., Paterson 4, N. J.
Vic Mfg. Co., Minneapolis, Minn.
★Waldron, John, Corp., New Brunswick, N. J.
Wilkinson Co., Akron 10, Ohio

COOLING TRAINS

★Adamson United Co., Akron 4, Ohio
★Black-Clawson Co., The, Dilts Div., Fulton, N. Y.
Continental Machinery Co., Inc., New York 7, N. Y.
Entwistle Mfg. Corp., Providence 7, R. I.
★Faeco Machine Co., Inc., Paterson, N. J.
★Goulding Mfg. Co., Saginaw, Mich.
Lembo Machine Works, Inc., Paterson 4, N. J.
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.

CUT-OFF MACHINES

Al-Be Industries, South Gate, Calif.
Allison-Campbell Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.
Barker-Davis Machine Co., Inc., Leominster, Mass.
Beck, Charles, Machine Corp., King of Prussia, Pa.
Boice-Crane Co., Toledo 6, Ohio
Brenner, I. G., Co., Newark Ohio
Buttondex Corp., New York 16, N. Y.
Continental Machinery Co., Inc., New York 7, N. Y.
★Covema s.r.l., Milan, Italy
★Cumberland Engineering Co., Inc., Providence 1, R. I.
★DoAll Co., The, Des Plaines, Ill.
Eisler Engineering Co., Inc., Newark 3, N. J.
Emery, Vern, Co., Sun Valley, Calif.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
★Famco Machine Co., Kenosha, Wis.
★Fecken-Kirfel Maschinenfabrik, Aachen, West Germany
Ferry Machine Co., Kent, Ohio
★Foster & Allen, Inc., Chatham, N. J.
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
★Hobbs Mfg. Co., Worcester 5, Mass.
★Hofmann & Schwabe K. G., Krefeld, West Germany
Industrial Plastics, Ltd., London W.1., England
★Johnson Machinery Co., Newark 5, N. J.
Ketchpel Engineering Co., West Englewood, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Mereen Johnson Machine Co., Minneapolis 12, Minn.
Motch & Merryweather Machinery Co., Cleveland 17, Ohio
★Progressive Machine Co., Inc., Paterson 4, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass.
Sommer & Maca Glass Machinery Co., Chicago 50, Ill.
Spadone Machine Co., Inc., S. Norwalk, Conn.

★ Indicates Advertiser

(For complete addresses, see Alphabetical Index, p. 1214)

Thermoplastic Equipment Corp., Div. of Thermoplastic Processes, Inc., Stirling, N. J.
Union Tool Corp., The, Warsaw, Indiana
Western Supplies Co., St. Louis 6, Missouri

CUTTERS
(See also Dicers)

A. *Guillotine*
B. *Multi-Layer Film*

★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany (A)
Blaw-Knox Co., Pittsburgh 22, Pa. (A, B)
★Clifton Hydraulic Press Co., Clifton, N. J. (A)
Continental Machinery Co., Inc., New York 7, N. Y. (A)
Custom Machine & Design, Inc., Akron 9, Ohio (A)
Eastman Machine Co., Buffalo 3, N. Y. (B)
Emery, Vern, Co., Sun Valley, Calif.
★Faeco Machine Co., Inc., Paterson, N. J. (A)
★Famco Machine Co., Kenosha, Wis. (A)
★Fecken-Kirfel Maschinenfabrik, Aachen, West Germany (A)
G & S Label Corp., New York 1, N. Y. (A)
★Gane Bros. & Lane, Inc., Chicago 7, Ill. (A)
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp. (A)
★Hobbs Mfg. Co., Worcester 5, Mass. (A)
★Johnson Machinery Co., Newark 5, N. J. (A)
★Karlton Machinery Corp., Chicago 11, Ill. (A)
Lawson Co., The, Div. of Miehle-Goss-Dexter, Inc., Chicago 8, Ill. (A)
★Liberty Machine Co., Inc., Paterson 4, N. J. (B)
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y. (A)
Miller, Franklin P., & Son, East Orange 16, N. J. (A)
★Omni Products Corp., New York 16, N. Y.
★Progressive Machine Co., Inc., Paterson 4, N. J. (A)
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany (A)
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J. (A)
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass. (A)
Spadone Machine Co., Inc., S. Norwalk, Conn. (A)
United Shoe Machinery Corp., Boston 7, Mass. (B)
Utility Mfg. Co., Cudahy, Wis. (A)
★Waldron, John, Corp., New Brunswick, N. J. (A)
Wysong & Miles Co., Greensboro, N. C. (A)

CUTTERS FOR FIBROUS GLASS

Abbe Engineering Co., New York 17, N. Y.
★Appleton Machine Co., Doven Div., Appleton, Wis.
Blaw-Knox Co., Pittsburgh 22, Pa.
Eastman Machine Co., Buffalo 3, N. Y.
Eisler Engineering Co., Inc., Newark 3, N. J.
Finn & Fram, Sunland, Calif.
★Foster & Allen, Inc., Chatham, N. J.

★ Indicates Advertiser

★Hobbs Mfg. Co., Worcester 5, Mass.
Maimin, H., Co., Inc., New York 18, N. Y.
Rand Development Corp., Cleveland 10, Ohio
Sommer & Maca Glass Machinery Co., Chicago 50, Ill.
Spadone Machine Co., Inc., S. Norwalk, Conn.
★Taylor Stiles & Co., Riegelsville, N. J.
Turner Machine Co., Inc., Danbury, Conn.

CYLINDERS

A. *Degassing, Liquid*
B. *Heating (For Injection Molding Machines)*
C. *Hydraulic*
D. *Pneumatic*

Airmatic Valve, Inc., Cleveland 9, Ohio (C, D)
Airoyal Mfg. Co., The, Maplewood, N. J. (C, D)
★Automatic Process Control, Union, N. J. (A, C, D)
Bellows Co., The, Akron 9, Ohio (C, D)
★Clifton Hydraulic Press Co., Clifton, N. J. (B, C, D)
★Dake Corp., Grand Haven, Mich. (C)
★Dunning & Boschert Press Co., Inc., The, Syracuse N. Y. (C)
★French Oil Mill Machinery Co., The, Piqua, Ohio (C)
Gerin Mfg. Co., Inc., Newark 7, N. J. (B)
Hanna Engineering Works, Chicago 22, Ill. (C, D)
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill. (C, D)
★Hydraulic Press Mfg. Co., The, A Div. of Koehring Co., Mount Gilead, Ohio (C)
Independent Machine Co., The, Cuyahoga Falls, Ohio (C, D)
★Injection Molders Supply Co., Cleveland 20, Ohio (B)
Lapeer Mfg. Co., Detroit 2, Mich. (C)
★Lawton, C. A., Co., The, DePere, Wis. (C, D)
Lembo Machine Works, Inc., Paterson 4, N. J. (C, D)
Lempco Industrial, Inc., Bedford, Ohio (C)
★Logan Hydraulics, Inc., Chicago 30, Ill. (C)
Machine Factory & Foundry Ltd., Netstal, Switzerland (B, C)
Mastro Plastics Corp., New York 67, N. Y. (B)
Mead Specialties Co., Inc., Chicago 41, Ill. (D)
Melt Extractor Mfg. Corp., New York 67, N. Y. (B)
★Miller Fluid Power Div., Flick-Reedy Corp., Bensenville, Ill. (C, D)
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa. (A)
Oilgear Co., The, Milwaukee 4, Wis. (C)
★Peco Machinery Sales (Westminster) Ltd., London, S.W.1., England (B)
★Rainville Co., Inc., The, Garden City, N. Y. (B)
Rodgers Hydraulic, Inc., Minneapolis 26, Minn. (C)
Valvair Corp., Akron 3, Ohio (C, D)
★Werner & Pfleiderer, Stuttgart, Germany (C)

DEFLASHING MACHINES

Anson Tools & Gages, Inc., Erie, Pa.
Buttondex Corp., New York 16, N. Y.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
Ferry Machine Co., Kent, Ohio
Foredom Electric Co., Inc., Bethel, Conn.
Gaynes Engineering Co., Chicago 12, Ill.
Ketchpel Engineering Co., W. Englewood, N. J.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
Lord Chemical Corp., York, Pa.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Merit Products, Inc., Los Angeles 16, Calif.
Nash, J. M., Co. Inc., Milwaukee, Wis.
Ransohoff Co., Hamilton, Ohio
R. R. Siebert Co., The, Rochester N. Y.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.
★Tumb-L-Matic, Inc., Stamford, Conn.
Wheelabrator Corp., Mishawaka, Ind.

DEGATING EQUIPMENT

Anson Tools & Gages, Inc., Erie Pa.
Barker-Davis Machine Co., Inc., Leominster, Mass.
★Buss Machine Works, Inc., Holland, Mich.
Buttondex Corp., New York 16, N. Y.
Industrial Plastics, Ltd., London W.1, England
★Injection Molders Supply Co., Cleveland 20, Ohio
★Lawton, C. A., Co., The, DePere, Wis.
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
★Standard Tool Co., Leominister, Mass.
★Sta-Warm Electric Co., Ravenna, Ohio
Stricker-Brunhaber Corp., New York 10, N. Y.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.

DICERS, CHOPPERS, AND CUTTERS

Abbe Engineering Co., New York 17, N. Y.
★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
★Alsteele Engineering Works, Inc., Framingham, Mass.
American Pulverizer Co., St. Louis, Mo.
Atlas-Sandt Corp., New York 11, N. Y.
★Ball & Jewell, Inc., Brooklyn 22, N. Y.
★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany
Blaw-Knox Co., Pittsburgh 22, Pa.
★Brosites Machine Co., Inc., New York 7, N. Y.
Buss, Ltd., Basel, Switzerland
Carbert Mfg. Co., Inc., Cambridge 39, Mass.
Colton, Arthur, Co., Div. of Snyder Corp., Detroit 7, Mich.
★Condux-Werk, Herbert A. Merges, K.G., Wolfgang/Hanau, West Germany
Continental Machinery Co., Inc., New York 7, N. Y.
★Covema s.r.l., Milan, Italy
★Cumberland Engineering Co., Inc., Providence 1, R. I.
Custom Machine & Design, Inc., Akron 9, Ohio
★DeMattia Machine & Tool Co., Clifton, N. J.
★Fecken-Kirfel Maschinenfabrik, Aachen, West Germany
Fellner & Ziegler G.m.b.H., Frankfurt/Main, West Germany
Ferry Machine Co., Kent, Ohio
★Foster & Allen, Inc., Chatham, N. J.
General Engineering Co., Radcliffe, Lancs., England
Hale & Kullgren, Inc., Akron, Ohio

★Hobbs Mfg. Co., Worcester 5, Mass.
Industrial Plastics, Ltd., London W.1, England
J M C Co., Newark 5, N. J.
★Johnson Machinery Co., Newark 5, N. J.
★Kato Seishakusho Co., Ltd., Tokyo, Japan
Lavorazione Materie Plastiche, S.A.S., Torino, Italy
Mitts & Merrill, Saginaw, Mich.
Miller, Franklin P., & Son, East Orange 16, N. J.
★Modern Plastic Machinery Corp., Lodi, N. J.
Motch & Merryweather Machinery Co., Cleveland 17, Ohio
★Omni Products Corp., New York 16, N. Y.
Pasquetti, Carlo, & C.S.A., Fabbrica Prodotti Termoplastici, Varese-Masnago, Italy
Radial Cutter Mfg. Corp., Elizabeth 4, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
Seymour, S. R., & Co., Ltd., Rayleigh, Essex, England
Spadone Machine Co., Inc., S. Norwalk, Conn.
Sprout, Waldron & Co., Inc., Muncy, Pa.
★Taylor Stiles & Co., Riegelsville, N. J.
★Thoreson-McCosh, Inc., Detroit 19, Mich.
★Van Dorn Iron Works Co., The, Cleveland 4, Ohio
★Windsor, R. H., Ltd., Chessington, England

DIES

(Clicker, Dinker, and Steel Rule)

A & S Steel Rule Die Corp., New York 2, N. Y.
Able Steel Rule Die Co., New York 12, N. Y.
Accurate Steel Rule Lie Mfrs., New York 10, N. Y.
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
Atlas-Sandt Corp., New York 11, N. Y.
Blaw-Knox Co., Pittsburgh 22, Pa.
Crucible Steel Co. of America, Pittsburgh 30, Pa.
★Entoleter Div., Safety Industries, Inc., New Haven, Conn.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
G & S Label Corp., New York 1, N. Y.
Independent Die & Supply Co., St. Louis 4, Mo.
Lansky Die Cutting Corp., Brooklyn 15, N. Y.
Payne Tool & Engineering Co., The Springfield, Ohio
Richards, J. A., Co., Kalamazoo, Mich.
Todaro, S., Co., Buffalo 1, N. Y.
★Tronomatic Machine Mfg. Corp., New York 35, N. Y.
United Shoe Machinery Corp., Boston 7, Mass.
Western Supplies Co., St. Louis 6, Mo.

DIES, CUTTING

A & S Steel Rule Die Corp., New York 2, N. Y.
Able Steel Rule Die Co., New York 12, N. Y.
Accurate Steel Rule Die Mfrs., New York 10, N. Y.
★Acromark Co., The, Elizabeth 4, N. J.
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
Atlantic Mfg. Co., Philadelphia 22, Pa.
Atlas-Sandt Corp., New York 11, N. Y.
Blaw-Knox Co., Pittsburgh 22, Pa.
Buss, Ltd., Basel, Switzerland
Pasquetti, Carlo, & C.S.A., Fabbrica Prodotti Termoplastici, Varese-Masnago, Italy
Continental Machinery Co., Inc., New York 7, N. Y.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
G & S Label Corp., New York 1, N. Y.
★Goulding Mfg. Co., Saginaw, Mich.
Independent Die & Supply Co., St. Louis 4, Mo.
Payne Tool & Engineering Co., The, Springfield, Ohio
Richards, J. A., Co., Kalamazoo, Mich.
Stricker-Brunhaber Corp., New York 10, N. Y.
Todaro, S., Co., Buffalo 1, N. Y.
★Tronomatic Machine Mfg. Corp., New York 35, N. Y.
United Shoe Machinery Corp., Boston 7, Mass.
Western Supplies Co., St. Louis 6, Mo.

DIES, EXTRUSION

(See Die Makers, Extrusion, p. 1148)

DRIERS AND PREHEATERS

(Non-Oven Types; See also Ovens)

A. *Electric, Gas, Hot Air, Steam Heat, Dehumidyfying*
B. *Infra-red*

★Abbé, Paul O., Inc., Little Falls, N. J. (A)
★Ball & Jewell, Inc., Brooklyn 22, N. Y. (A)
★Black-Clawson Co., The, Dilts Div., Fulton, N. Y. (A)
Blaw-Knox Co., Pittsburgh 22, Pa. (A)
★Blue, E. B., Co., S. Norwalk, Conn. (A, B)
Buss, Ltd., Basel, Switzerland (A)
Carpco Mfg., Inc., Jacksonville 6, Fla. (A)
Continental Machinery Co., Inc., New York 7, N. Y. (A, B)
Dawson, F. C., Engineering Co., Canton, Mass. (A)
Dean Thermo-Panel Coil Div., Dean Products, Inc., Brooklyn 38, N. Y. (A)
DeVilbiss Co., The, Toledo 1, Ohio (A)
Devine, J. P., Mfg. Co., Pittsburgh 1, Pa. (A)
Doyle, J. E., Co., Cleveland 13, Ohio (A, B)
Dryomatic Corp., Alexandria, Va. (A)
Falcon Equipment Co., New Brighton, Pa. (A)
Faratron, Los Angeles 23, Calif.
Fostoria Pressed Steel Corp., The, Fostoria, Ohio (A)
General Research & Supply Co., Grand Rapids 3, Mich. (A)
Girdler Process Equipment Div., Chemetron Corp., Louisville 1, Ky. (A)
★Glenn Electric Heater Corp., Newark 8, N. J. (A, B)
★Goulding Mfg. Co., Saginaw, Mich.
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y. (A)
Hedin, Ltd., London E. 18, England (A, B)
Herbert Products, Inc., Woodhaven 21, N. Y. (A, B)
Infra-Red Systems Inc., Riverdale, N. J. (B)
★Johnson Mfg. Co., Inc., Chippewa Falls, Wis. (A)
★Kleinewefers, Joh., Söhne, Krefeld, West Germany (A, B)
★Litzler, C. A., Co., Inc., Cleveland 9, Ohio (A, B)
★Lydon Bros., Inc., Hackensack, N. J. (A)
Miskella Infra-Red Co., Inc., The, Cleveland 4, Ohio (A, B)
★Mitchell Specialty Div., Industrial Enterprises, Inc.., Philadelphia 36, Pa. (A)
Monkley Corp., Worcester 8, Mass. (A)
★Moslo Machinery Co., Cleveland 15, Ohio (A)
★Omni Products Corp., New York 16, N. Y.
Patterson Foundry and Machine Co., The, E. Liverpool, Ohio (A)
Patterson-Kelley Co., Inc., The, E. Stroudsburg, Pa. (A)
Proctor & Schwartz, Inc., Philadelphia 20, Pa. (A)
★Rainville Co., Inc., The, Garden City, N. Y. (A)
★Sta-Warm Electric Co., Ravenna, Ohio (A)
★Stokes, F. J., Corp., Philadelphia 20, Pa. (B)
Thermomat Co. Inc., Trenton 8, N. J. (A)
★Thoreson-McCosh, Inc., Detroit 19, Mich. (A)
Toko Machine Industry Co., Ltd., Tokyo, Japan (A, B)
Tower Iron Works, Inc., Providence 1, R. I. (A)
Whitaker, Douglas C., Co., Glenside, Pa. (A)
★Whitlock Associates, Inc., Oak Park 37, Mich. (A)
★Wiegand, Edwin L., Co., Pittsburgh 8, Pa. (A)
Wilkinson Co., Akron 10, Ohio (A)
Wyssmont Co., Inc., Long Island City 1, N. Y. (A)
Zack Radiant Heat Co., Lodi, N. J. (A)

DRIVES, VARIABLE SPEED

Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
Blaw-Knox Co., Pittsburgh 22, Pa.
Carpco Mfg., Inc., Jacksonville 6, Fla.
Eaton Mfg. Co., Dynamatic Div., Kenosha, Wis.
Ferry Machine Co., Kent, Ohio
★General Electric Co., Apparatus Sales Div., Schenectady 5, N. Y.
Industrial Plastics, Ltd., London W.1, England
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Mercury Industries, Inc., Hillsdale, N. J.
Monkley Corp., Worcester 8, Mass.
Mount Hope Machinery Co., Taunton, Mass.
Oilgear Co., The, Milwaukee 4, Wis.
★Omni Products Corp., New York 16, N. Y.
★Reliance Electric & Engineering Co., Cleveland 17, Ohio
★Servospeed Div., Electro-Devices, Inc., Paterson, N. J.
★Shaw, Francis, & Co., Ltd., Manchester 11, England
Stanford Engineering Co., Salem, Ill.
Sterling Electric Motors, Inc., Los Angeles 22, Calif.
Wallace, L. R., & Co., Pasadena 1, Calif.
Web Controls Corp., W. Englewood, N. J.
Worthington Corp., Harrison, N. J.

DUST COLLECTING EQUIPMENT

American Agile Corp., Bedford, Ohio
DeVilbiss Co., The, Toledo 1, Ohio
Dracco Div. of Fuller Co., Cleveland 5, Ohio

★ Indicates Advertiser

Electric Trading Co., New York 13, N. Y.
Fisher Scientific Co., Pittsburgh 19, Pa.
Flexaust Co., The, New York 17, N. Y.
Pangborn Corp., Hagerstown, Md.
Pulverizing Machinery Div., Metals Disintegrating Co., Inc., Summit, N. J.
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass.
Wallace & Tiernan, Inc., Belleville 9, N. J.
Wheelabrator Corp., Mishawaka, Ind.
Young Machinery Co., The, Inc., Muncy, Pa.

EMBOSSING PRESSES

★Ackerman Gould Co., Oceanside, N. Y.
★Acromark Co., The, Elizabeth 4, N. J.
★Apex Machine Co., College Point 56, N. Y.
Atlas Hydraulics Div., Delaware Valley Mfg. Co., Inc., Philadelphia 34, Pa.
Atlas-Sandt Corp., New York 11, N. Y.
★Black-Clawson Co., The, Dilts Div., Fulton, N. Y.
Bliss, E. W., Co., Canton 10, Ohio
★Clifton Hydraulic Press Co., Clifton, N. J.
★Dake Corporation, Grand Haven, Mich.
Defiance Machine & Tool Co., St. Louis 10, Mo.
Dornbusch & Co., Krefeld, West Germany
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio
★Faeco Machine Co., Inc., Paterson, N. J.
Falge Engineering Corp., Bethesda 14, Md.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
★Famco Machine Co., Kenosha, Wis.
★French Oil Mill Machinery Co., The, Piqua, Ohio
G & S Label Corp., New York 1, N. Y.
Heinrich Equipment Corp., New York 11, N. Y ., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
Inta Roto Machine Co., Richmond 3, Va.
International Engraving Corp., Cedar Grove, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
Lavorazione Materie Plastiche, S. A. S., Torino, Italy
★Lawton, C. A., Co., The, DePere, Wis.
★Liberty Machine Co., Inc., Paterson 4, N. J.
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
Modern Engraving & Machine Co., Hillside, N. J.
Monkley Corp., Worcester 8, Mass.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
Rodgers Hydraulic, Inc., Minneapolis 26, Minn.
Shannon, Alexander J., Co., The, New York 38, N. Y.
Swan Machine Co., New York 1, N. Y.
Thomson-National Press Co., Franklin, Mass.
Toko Machine Industry Co., Ltd., Tokyo, Japan
Union Tool Corp., The, Warsaw, Ind.
Verduin, John, Machine Corp., Paterson 4, N. J.
Verson Allsteel Press Co., Chicago 19, Ill.
★Werner & Pfleiderer, Stuttgart, West Germany
★Wood, R. D., Co., Philadelphia 5, Pa.

★ Indicates Advertiser

EXTRUDERS

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany
★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany
Blaw-Knox Co., Pittsburgh 22, Pa.
★Bonnot Co., The, Canton 2, Ohio
Buss, Ltd., Basel, Switzerland
★Chandler Equipment Engineering Co., Anaheim, Calif.
★Covema s.r.l., Milan, Italy
★Davis-Standard Div., Franklin Research Corp., Mystic, Conn.
★Egan, Frank W., & Co., Somerville, N. J.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
Fischer, Johann, Machinenbau, Lohmar, Bez., Cologne, West Germany
Hale & Kullgren, Inc., Akron, Ohio
★Hartig Extruders Div., Midland-Ross Corp., Mountainside, N. J.
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
★Henschel-Werke Gmbh, Kassel, West Germany
Iddon Brothers Ltd., Leyland, Lancashire, England
Industrial Plastics, Ltd., London W.1, England
J M C Co., Newark 5, N. J.
★Johnson Machinery Co., Newark 5, N. J.
★Kato Seishakusho Co., Ltd., Tokyo, Japan
★Killion Tool & Mfg. Co., Verona, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
Lavorazione Materie Plastiche, S.A.S., Torino, Italy
★Modern Plastic Machinery Corp., Lodi, N. J.
★National Rubber Machinery Co., Akron 8, Ohio
★Negri Bossi & Co., Milan, Italy
★Omni Products Corp., New York 16, N. Y.
Pasquetti, Carlo, & C.S.A., Fabbrica Prodotti Termoplastici, Varese-Masnago, Italy
★Peco Machinery Sales (Westminster) Ltd., London, S.W.1., England
★Prodex Corp., Fords, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
★Royle, John, & Son, Paterson 3, N. J.
★Shaw, Francis, & Co., Ltd., Manchester 11, England
★Sterling Extruder Corp., Linden, N. J.
★Thermoplastic Equipment Corp., Div. of Thermoplastic Processes, Inc., Stirling, N. J.
★Thermoplastic Processes, Inc., Stirling, N. J.
Troester, Paul, Maschinenfabrik, Hannover, Wulfel, West Germany
Wayne Machine & Die Co., Passaic, N. J.
★Welding Engineers, Inc., Bridgeport, Pa.
★Werner & Pfleiderer, Stuttgart, West Germany
★Windsor, R. H., Ltd., Chessington, England

FILM CASTING MACHINES

American Products Mfg. Co., New Orleans 18, La.
Blaw-Knox Co., Pittsburgh 22, Pa.
★Egan, Frank W., & Co., Somerville, N. J.
★Faeco Machine Co., Inc., Paterson, N. J.
H & R Industries, Nazareth, Pa.
★Hartig Extruders Div., Midland-Ross Corp., Mountainside, N. J.
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
★Hofmann & Schwabe K.G., Krefeld, West Germany
Industrial Plastics, Ltd., London W.1, England
★Liberty Machine Co., Inc., Paterson 4, N. J.
★Modern Plastic Machinery Corp., Lodi, N. J.
★Omni Products Corp., New York 16, N. Y.
★Prodex Corp., Fords, N. J.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
★Robbins Plastic Machinery Corp., Elkhart, Ind.
★Waldron, John, Corp., New Brunswick, N. J.

FILM CUTTERS

Blaw-Knox Co., Pittsburgh 22, Pa.
Eastman Machine Co., Buffalo 3, N. Y.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
★Hobbs Mfg. Co., Worcester 5, Mass.
★Hofmann & Schwabe K.G., Krefeld, West Germany
Industrial Plastics, Ltd., London W.1, England
Maimin, H., Co., Inc., New York 18, N. Y.
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Ruf Machine Co., Inc., New York 28, N. Y.
★Waldron, John, Corp., New Brunswick, N. J.

FILTERS AND OIL PURIFIERS

Indiana Commercial Filter Corp., Lebanon, Ind.
★Marvel Engineering Co., Chicago 45, Ill.
Pyramid Screen Corp., Brookline 46, Mass.
★Rainville Co., Inc., The, Garden City, N. Y.
Read Standard, Div. of Capitol Products Corp., York, Pa.
Shriver, T., & Co., Inc., Harrison, N. J.

FLEXOGRAPHIC PRINTING PRESSES

★Black-Clawson Co., The, Dilts Div., Fulton, N . Y.
★Faeco Machine Co., Inc., Paterson, N. J.
★Hamac Packmaschinen GmbH, Dusseldorf, West Germany
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
Industrial Marking Equipment Co., Inc., Brooklyn 8, N. Y.
Inta Roto Machine Co., Richmond 3, Va.
Lembo Machine Works, Inc., Paterson 4, N. J.
★Liberty Machine Co., Inc., Paterson 4, N. J.
Modern Engraving & Machine Co., Hillside, N. J.
★Omni Products Corp., New York 16, N. Y.
★Rainville Co., Inc., The, Garden City, N. Y.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
Shannon, Alexander J., Co., The, New York 38, N. Y.
Swan Machine Co., New York 1, N. Y.

★Waldron, John, Corp., New Brunswick, N. J.
Web Controls Corp., W. Englewood, N. J.

FOAMING MACHINES

★Automatic Process Control, Union, N. J.
B. B. Chemical Co., Cambridge 39, Mass.
★Dayton Rubber Co., The, Dayton, Ohio
Dennis Chemical Co., St. Louis 3, Mo.
Farbenfabriken-Bayer, A. G., Leverkusen, West Germany
★Fecken-Kirfel Maschinenfabrik, Aachen, West Germany
Girdler Process Equipment Div., Chemetron Corp., Louisville 1, Ky.
★Goulding Mfg. Co., Saginaw, Mich.
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y.
★Hull Corp., Hatboro, Pa.
Isocyanate Products, Inc., New Castle, Del.
Jennings Engineering Co., Philadelphia 4, Pa.
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
★Rainville Co., Inc., The, Garden City, N. Y.
Sweets, Martin, Co., The, Louisville 2, Ky.
Whitaker, Douglas C., Co., Glenside, Pa.

FRAZING MACHINES

Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.

GAGES

(See Instruments)

GENERATORS, STEAM

(See Boilers)

GRANULATORS

(See Dicers)

HAND-OPERATED COMPRESSION PRESSES

(See Compression Presses)

HAND-OPERATED INJECTION MOLDING MACHINES

(See Injection Molding Machines)

HANDLING DEVICES FOR EXTRUDED PRODUCTS

(Expanders, Guiders, Shape-handling Equipment, Stackers, Sheeters, etc.)

★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
Al-Be Industries, South Gate, Calif.
Blaw-Knox Co., Pittsburgh 22, Pa.
★Egan, Frank W., & Co., Somerville, N. J.
Ferry Machine Co., Kent, Ohio
Fife Mfg. Co., Oklahoma City 18, Okla.
Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany
★Goulding Mfg. Co., Saginaw, Mich.
★Hartig Extruders Div., Midland-Ross Corp., Mountainside, N. J.
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
Heppenstall Co., Pittsburgh 1, Pa.
★Hobbs Mfg. Co., Worcester 5, Mass.
Industrial Plastics, Ltd., London W. 1., England
J M C Co., Newark 5, N. J.
★Johnson Mfg. Co., Inc., Chippewa Falls, Wis.
Lewis-Shepard Products, Inc., Watertown 72, Mass.
★Modern Plastic Machinery Corp., Lodi, N. J.
Mount Hope Machinery Co., Taunton, Mass.
★Omni Products Corp., New York 16, N. Y.
★Prodex Corp., Fords, N. J.
★Progressive Machine Co., Inc., Paterson 4, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
★Robbins Plastic Machinery Corp., Elkhart, Ind.
★Sterling Extruder Corp., Linden, N. J.
★Windsor, R. H. Ltd., Chessington, England

HEATING EQUIPMENT

(For Molds and Molding Machines)

American Hydrotherm Corp., Long Island City 1, N. Y.
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England
Blaw-Knox Co., Pittsburgh 22, Pa.
★Blue, E. B., Co., S. Norwalk, Conn.
Briscoe Mfg. Co., Columbus 3, Ohio
Buss, Ltd., Basel, Switzerland
★Clifton Hydraulic Press Co., Clifton, N. J.
Conapac Corp., New York 3, N. Y.
Cooper, D. C., Co., Chicago 5, Ill.
Dean Thermo-Panel Coil Div., Dean Products, Inc., Brooklyn 38, N. Y.
Devco Engineering, Inc., Caldwell, N. J.
Electric Trading Co., New York 13, N. Y.
Erinac Equipment Corp., New York 12, N. Y.
Falcon Equipment Co., New Brighton, Pa.
★General Electric Co., Apparatus Sales Div., Schenectady 5, N. Y.
Gerin Mfg. Inc., Newark 7, N. J.
★Glenn Electric Heater Corp., Newark 8, N. J.
Grieve-Hendry Co., Inc., Chicago 7, Ill.
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y.
Hedin, Ltd., London E. 18, England
Hotwatt, Inc., Danvers, Mass.
★Improved Machinery, Inc., Nashua, N. H.
★Industrial Heater Co., Inc., New York, N. Y.
★Industrial Mfg. Corp., Indianapolis 4, Ind.
★Injection Molders Supply Co., Cleveland 20, Ohio
★Mercury Molding Machinery, Inc., Yonkers, N. Y.
★Omni Products Corp., New York 16, N. Y.
★Pantex Mfg. Corp., Pawtucket, R. I.
Powers Regulator Co., The, Skokie 34, Ill.
★Rainville Co., The, Inc., Garden City, N. Y.
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Rockwell, W. S., Co., Fairfield, Conn.
★Sterling, Inc., Milwaukee 18, Wis.
★Thermel, Inc., Franklin Park, Ill.
Verduin, John, Machine Corp., Paterson 4, N. J.
Watlow Electric Mfg., Co., St. Louis 14, Mo.
★Wiegand, Edwin L., Co., Pittsburgh 8, Pa.

HEAT SEALING EQUIPMENT

A & S Steel Rule Die Corp., New York 2, N. Y.
Able Steel Rule Die Co., New York 12, N. Y.
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
Amperex Electronic Corp., Hicksville, N. Y.
★Atlas Vac-Machine Corp., Rochester 21, N. Y.
Barr Corp., The, Richmond Hill, N. Y.
Bemis Bro. Bag Co., St. Louis 2, Mo.
Blaw-Knox Co., Pittsburgh 22, Pa.
★Callanan, J. A., Co., Chicago 6, Ill.
Carbert Mfg. Co., Inc., Cambridge 39, Mass.
Chaffee, Ralph, & Co., San Francisco 14, Calif.
★Cosmos Electronic Machine Corp., New York 12, N. Y.
★Cosom Engineering Corp., Minneapolis 16, Minn.
★D & R Plastic Welders, Inc., Hazardville, Conn.
Emhart Mfg. Co., Portland Div., Portland, Conn.
Erdco Engineering Corp., Addison, Ill.
Faratron, Los Angeles 23, Calif.
France Engineering Co., The, Cleveland 11, Ohio
★Glenn Electric Heater Corp., Newark 8, N. J.
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y.
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
Hotwatt, Inc., Danvers, Mass.
Independent Die & Supply Co., St. Louis 4, Mo.
★Johnson Machinery Co., Newark 5, N. J.
Kabar Mfg. Corp., New York 62, N. Y.
Kel-Min Co., Middle Field, Ohio
★Liberty Machine Co., Inc., Paterson 4, N. J.
★Mayflower Electronic Devices, Inc., Little Ferry, N. J.
Mercury Heat Sealing Equipment Co., Philadelphia 33, Pa.
★Omni Products Corp., New York 16, N. Y.
Packaging Industries Ltd., Inc., Montclair, N. J.
★Peterson, A. W., & Sons Die Co., Inc., New York 12, N. Y.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastic Welding Corp., Newark, N. J.
★Possis Machine Corp., Minneapolis 3, Minn.
Product Packaging Engineering, Culver City, Calif.
Raybond Electronics, Inc., Newton 61, Mass.
Reeve Electronics, Inc., Chicago 6, Ill.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
Rotobond Co., Bound Brook, N. J.
★Sealomatic Electronics Corp., Brooklyn, 11, N. Y.
★Thermatron Co., The, Div. of Willcox & Gibbs Sewing Machine Co., New York 18, N. Y.
★Tronomatic Machine Mfg. Corp., New York 35, N. Y.
★Vertrod Corp., Brooklyn 34, N. Y.
★Wiegand, Edwin L., Co., Pittsburgh 8, Pa.
Zeva-Elektrizitats, Ges., Arolsen, West Germany

★ Indicates Advertiser

HEAT SEALING MACHINES

A. High Frequency
B. Thermal, Non-Portable
C. Thermal, Portable

Able Steel Rule Die Co., New York 12, N. Y. (A)
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio (C)
Barr Corp., The, Richmond Hill, N. Y. (A)
★Callanan, J. A., Co., Chicago 6, Ill. (A, B)
Carbert Mfg. Co., Inc., Cambridge 39, Mass. (B, C)
★Cosmos Electronic Machine Corp., New York 12, N. Y. (A)
★Cosom Engineering Corp., Minneapolis 16, Minn. (B)
★D & R Plastic Welders, Inc., Hazardville, Conn. (C)
Erdco Engineering Corp., Addison, Ill. (A)
Faratron, Los Angeles 23, Calif. (A)
France Engineering Co., The, Cleveland 11, Ohio (C)
Girdler Process Equipment Div., Chemetron Corp., Louisville 1, Ky. (A)
★Glenn Electric Heater Corp., Newark 8, N. J. (B, C)
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y. (A)
★Hamac Packmaschinen GmbH, Dusseldorf, West Germany (B)
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp. (B)
Industrial Plastics, Ltd., London W. 1., England (B)
Kabar Mfg. Corp., New York 62, N. Y. (A)
★Mayflower Electronic Devices, Inc., Little Ferry, N. J. (A, B, C)
Mercury Heat Sealing Equipment Co., Philadelphia 33, Pa. (B, C)
★Omni Products Corp., New York 16, N. Y. (A, B, C)
Packaging Industries Ltd., Inc., Montclair, N. J. (B)
★Peterson, A. W., & Sons Die Co., Inc., New York 12, N. Y. (A)
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga. (B, C)
Plastic Welding Corp., Newark, N. J. (A)
Product Packaging Engineering, Culver City, Calif. (B, C)
Radio Frequency Co., Inc., Medfield, Mass. (A)
Raven Industries, Inc., Sioux Falls, S. D. (C)
Raybond Electronics, Inc., Newton 61, Mass. (A)
Reeve Electronics, Inc., Chicago 6, Ill. (A)
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany (B)
★Sealomatic Electronics Corp., Brooklyn 11, N. Y. (A, B)
★Seidensha Electronical Mfg. Co., Ltd., Tokyo, Japan (A)
Sherman Industrial Electronics, State College, Pa. (A)
Societe de L'Electronique Fse., Asnieres, Seine, France (A)
★Thermatron Co., The, Div. of Willcox & Gibbs Sewing Machine Co., New York 18, N. Y. (A, B, C)
★Tronomatic Machine Mfg. Corp., New York 35, N. Y. (B, C)
★Vertrod Corp., Brooklyn 34, N. Y. (B, C)
Western Supplies Co., St. Louis 6, Mo. (A)

★ Indicates Advertiser

HIGH-FREQUENCY PREHEATING EQUIPMENT

Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
Cooper, D. C., Co., Chicago 5, Ill.
Faratron, Los Angeles 23, Calif.
Girdler Process Equipment Div., Chemetron Corp., Louisville 1, Ky.
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y.
La Rose, W. T., & Assoc., Inc., Troy, N. Y.
★Mayflower Electronic Devices, Inc., Little Ferry, N. J.
Plastic Welding Corp., Newark, N. J.
Radio Frequency Co., Inc., Medfield, Mass.
★Rainville Co., Inc., The, Garden City, N. Y.
Raybond Electronics, Inc., Newton 61, Mass.
Reeve Electronics, Inc., Chicago 6, Ill.
★Sealomatic Electronics Corp., Brooklyn 11, N. Y.
Sherman Industrial Electronics, State College, Pa.
Societe de L'Electronique Fse., Asnieres, Seine, France
★Symons, Ralph B., Associates, Inc., Tiverton, R. I.
★Thermatron Co., The, Div., of Willcox & Gibbs Sewing Machine Co., New York 18, N. Y.
Timadco, Inc., Mineola, N. Y.
Young Bros. Co., Cleveland 13, Ohio

HOBBING PRESSES

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
Albert, P. E., & Son, Trenton 5, N. J.
Atlas Hydraulics Div., Delaware Valley Mfg. Co., Inc., Philadelphia 34, Pa.
★Becker & Van Hullen, Krefeld, West Germany
Bliss, E. W., Co., Canton 10, Ohio
★Clifton Hydraulic Press Co., Clifton, N. J.
★Dake Corp., Grand Haven, Mich.
★Daniels, T. H. & J., Ltd., Stroud, Gloucestershire, England
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio
★Erie Foundry Co., Erie, Pa.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
★French Oil Mill Machinery Co., The, Piqua, Ohio
★Johnson Machinery Co., Newark 5, N. J.
★Karlton Machinery Corp., Chicago 11, Ill.
Lake Erie Machinery Corp., Buffalo 17, N. Y.
★Lawton, C. A., Co., The, DePere, Wis.
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
Machine Factory & Foundry Ltd., Netstal, Switzerland
Rodgers Hydraulic, Inc., Minneapolis 26, Minn.
Verson Allsteel Press Co., Chicago 19, Ill.
★Wood, R. D., Co., Philadelphia 5, Pa.

HOPPER DRYERS

(See Driers and Preheaters)

HOPPER LOADERS

Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany
★Goulding Mfg. Co., Saginaw, Mich.
Industrial Plastics, Ltd., London W.1., England
★Injection Molders Supply Co., Cleveland 20, Ohio
Ketchpel Engineering Co., W. Englewood, N. J.
★Omni Products Corp., New York 16, N. Y.
Rainco Mfg., Inc., Franklin, Pa.
★Rainville Co., Inc., The, Garden City, N. Y.
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Spencer Turbine Co., Hartford 6, Conn.
★Thoreson-McCosh, Inc., Detroit 19, Mich.
★Whitlock Associates, Inc., Oak Park 37, Mich.

HYDRAULIC POWER SYSTEMS

★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England
Berthelsen Engineering, Joliet, Ill.
★Clifton Hydraulic Press Co., Clifton, N. J.
★Consolidated Baling Machine Co., Brooklyn 15, N. Y.
Continental Machinery Co., Inc., New York 7, N. Y.
★Dake Corp., Grand Haven, Mich.
★Erie Engine & Mfg. Co., Erie, Pa.
★French Oil Mill Machinery Co., The, Piqua, Ohio
GPE Controls, Inc., Chicago 11, Ill.
★Goulding Mfg. Co., Saginaw, Mich.
Greer Hydraulics, Inc., Jamaica 30, N. Y.
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill.
★Harvey, Guy P., & Son Corp., Leominster, Mass.
★Hull-Standard Corp., Hatboro, Pa.
★Hydraulic Press Mfg. Co., The, A Div. of Koehring Co., Mount Gilead, Ohio
★Johnson Machinery Co., Newark 5, N. J.
Kabar Mfg. Corp., New York 62, N. Y.
★Karlton Machinery Corp., Chicago 11, Ill.
★Lawton, C. A., Co., The, DePere, Wis.
★Logan Hydraulics, Inc., Chicago, Ill.
Machine Factory & Foundry Ltd., Netstal, Switzerland
★Mayflower Electronic Devices, Inc., Little Ferry, N. J.
Oilgear Co., The, Milwaukee 4, Wis.
★Possis Machine Corp., Minneapolis 3, Minn.
Racine Hydraulics & Machinery, Inc., Racine, Wis.
Rodgers Hydraulic, Inc., Minneapolis 26, Minn.
G. Siempelkamp & Co., Krefeld, Germany
Stanford Engineering Co., Salem, Ill.
★Symons, Ralph B., Associates, Inc., Tiverton, R. I.
★Werner & Pfleiderer, Stuttgart, Germany
★Wood, R. D., Co., Philadelphia 5, Pa.

HYDRAULIC PRESSES

(See Compression Molders, Trimming Presses, etc.)

IMPREGNATING MACHINES

★Black-Clawson Co., The, Dilts Div., Fulton, N. Y.
Blaw-Knox Co., Pittsburgh 22, Pa.
Continental Machinery Co., Inc., New York 7, N. Y.
Cooper, D. C., Co., Chicago 5, Ill.
Devine, J. P., Mfg. Co., Pittsburgh 1, Pa.
Edwards High Vacuum, Inc., Niagara Falls, N. Y.
★Egan, Frank W., & Co., Somerville, N. J.
★Faeco Machine Co., Inc., Paterson, N. J.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.

General Engineering Co., Radcliffe, Lancs., England
High Vacuum Equipment Corp., Hingham, Mass.
★Hofmann & Schwabe K.G., Krefeld, West Germany
★Hull Corp., Hatboro, Pa.
★Industrial Ovens, Inc., Cleveland 11, Ohio
★Liberty Machine Co., Inc., Paterson 4, N. J.
★Litzler, C. A., Co., Inc., Cleveland 9, Ohio
Mateer, G. Diehl, Co., Wayne, Pa.
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
★NRC Equipment Corp., Newton 61, Mass.
Nureco, Inc., Cranston 10, R. I.
Seal Cast Co., Inc., Philadelphia 25, Pa.
Shannon, Alexander J., Co., The, New York 38, N. Y.
Sherman Rubber Co., Div. of Botwinik Bros., Inc., Worcester, Mass.
★Stokes, F. J., Corp., Philadelphia, Pa.
★Waldron, John, Corp., New Brunswick, N. J.

INJECTION MOLDING MACHINES

A. Fully Automatic
B. Semi-Automatic
C. Hand-Operated

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y. (A, B, C)
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany (A, B)
★Becker & Van Hullen, Krefeld, West Germany (A, B)
Blaw-Knox Co., Pittsburgh, Pa. (A, B, C)
British Machines & Foundry Supplies, Ltd., Port Washington, N. Y. (C)
★Brosites Machine Co., Inc., New York 7, N. Y. (A, B)
★Clifton Hydraulic Press Co., Clifton, N. J. (A, B)
★Covema s.r.l., Milan, Italy (A, B, C)
Crown Machine & Tool Co., Fort Worth 7, Texas (A)
★Daniels, T. H. & J. Ltd., Stroud, Gloucestershire, England (A, B)
★DeMattia Machine & Tool Co., Clifton, N. J. (A, B)
★Dowding & Doll, Ltd., London W.14, England (A, B, C)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A, B)
★Fellows Gear Shaper Co., The, Plastics Machine Div., Springfield, Vermont (A, B)
★Harvey, Guy P., & Son Corp., Leominster, Mass. (A)
★Hydraulic Press Mfg. Co., The, A Div. of Koehring Co., Mount Gilead, Ohio (A, B)
★Improved Machinery, Inc., Nashua, N. H. (A, B)
Industrial Plastics, Ltd., London W.1, England (A, B, C)
★Johnson Machinery Co., Newark 5, N. J. (A, B, C)
★Karlton Machinery Corp., Chicago 11, Ill. (A, B)
★Kato Seishakusho Co., Ltd., Tokyo, Japan
★Lester Engineering Co., Cleveland 13, Ohio (A, B)
★Lewis Welding & Engineering Corp., Bedford, Ohio (A, B)
★Lombard Governor Corp., Ashland, Mass. (A, B)
Machine Factory & Foundry Ltd., Netstal, Switzerland (A, B, C)
Meiki Co., Ltd., Nagoya, Japan (A)
★Moslo Machinery Co., Cleveland 15, Ohio (A)
★National Automatic Tool Co., Richmond, Ind. (A, B)
★Negri Bossi & Co., Milan, Italy (A, B, C)
★Newbury Industries, Inc., Newbury, Ohio (A, B, C)
★Omni Products Corp., New York 16, N. Y.
★Peco Machinery Sales (Westminster), Ltd., London, S.W.1., England (A, B)
★Rainville Co., Inc., The, Garden City, N. Y. (A, B)
★Reed-Prentice Div., Package Machinery Co., E. Longmeadow, Mass. (A, B)
Seymour, S. R., & Co., Ltd., Rayleigh, Essex, England (C)
★Shaw, Francis, & Co., Ltd., Manchester 11, England (C)
★Simplomatic Mfg. Co., Chicago 51, Ill. (A)
★Standard Tool Co., Leominster, Mass. (A)
★Stokes, F. J., Corp., Philadelphia 20, Pa. (A)
★Triulzi, A. Off., s.a.s. Milan, Italy (A, B, C)
★Van Dorn Iron Works Co., The, Cleveland 4, Ohio (A, B, C)
★Watson-Stillman Press Div., Farrel-Birmingham Co., Inc., Rochester 10, N. Y. (A, B, C)
★Windsor, R. H., Ltd., Chessington, England (A, B, C)

IRRADIATION EQUIPMENT

★Aerojet-General Nucleonics, San Ramon, Calif.
★General Electric Co., Apparatus Sales Div., Schenectady 5, N. Y.
High Voltage Engineering Corp., Burlington, Mass.

KETTLES, RESIN

Artisan Metal Products, Inc., Waltham 54, Mass.
Blaw-Knox Co., Pittsburgh 22, Pa.
Cooper, D. C., Co., Chicago 5, Ill.
Crawford Russell, Inc., Stamford, Conn.
Dean Thermo-Panel Coil Div., Dean Products, Inc., Brooklyn 36, N. Y.
Devine, J. P., Mfg. Co., Pittsburgh, Pa.
Falcon Equipment Co., New Brighton, Pa.
Ferro Corp., Patterson Equipment Div., East Liverpool, Ohio
First Machinery Corp., Brooklyn, N. Y.
Patterson Foundry and Machine Co., The, E. Liverpool, Ohio
Patterson-Kelley Co. Inc., The, E. Stroudsburg, Pa.
Process Engineering & Machine Co., Inc., Elizabeth, N. J.
Ross, Charles, & Son Co., Brooklyn 5, N. Y.
★Sta-Warm Electric Co., Ravenna, Ohio
Tower Iron Works, Inc., Providence 1, R. I.
★Windsor, R. H., Ltd., Chessington, England

KNEADERS AND MIXERS

(See Extruders, Mills, Intensive Mixers)

LABELING AND DECORATING MACHINES

★Acromark Co., The, Elizabeth 4, N. J.
★Apex Machine Co., College Point 56, N. Y.
Brady, W. H., Co., Milwaukee 9, Wis.
Carbert Mfg. Co., Inc., Cambridge 39, Mass.
★Cosmos Electronic Machine Corp., New York 12, N. Y.
Defiance Machine & Tool Co., St. Louis 10, Mo.
Dennison Mfg. Co., Framingham, Mass.
G & S Label Corp., New York 1, N. Y.
General Research & Supply Co., Grand Rapids 3, Mich.
International Eastern Co., New York 1, N. Y.
Ketchpel Engineering Co., W. Englewood, N. J.
Long & Co. Inc., Baltimore 15, Md.
Markem Machine Co., Keene, N. H.
Mercury Heat Sealing Equipment Co., Philadelphia 33, Pa.
New Jersey Machine Corp., Hoboken 1, N. J.
★Olsenmark Corp., New York 13, N. Y.
★Omni Products Corp., New York 16, N. Y.
Rutherford Machinery Co., Div. of Sun Chemical Corp., East Rutherford, N. J.
Screen-O-Printer Mfg. Co., Adams, Mass.

LAMINATING PRESSES

A. High-Pressure Laminates
B. Thermoplastic Sheet Laminating Press

★Adamson United Co., Akron 4, Ohio (A, B)
Albert, P. E., & Son, Trenton 5, N. J. (A, B)
Atlas Hydraulics Div., Delaware Valley Mfg. Co., Inc., Philadelphia 34, Pa. (A, B)
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa. (A)
★Becker & Van Hullen, Krefeld, West Germany (A, B)
★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany (B)
Berthelsen Engineering, Joliet, Ill. (A, B)
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa. (B)
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio (A, B)
Bradley & Turton, Ltd., Kidderminster, England (A)
★Carver, Fred S., Inc., Summit, N. J. (B)
Clearing Div. of U. S. Industries, Inc., Chicago 38, Ill. (A)
★Clifton Hydraulic Press Co., Clifton, N. J. (A, B)
★Consolidated Baling Machine Co., Brooklyn 15, N. Y. (A, B)
Dornbusch & Co., Krefeld, West Germany (B)
★Dunning & Boschert Press Co., Inc., The, Syracuse, N. Y. (A, B)
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio (A, B)
★Erie Engine Mfg. Co., Erie, Pa. (A, B)
★Erie Foundry Co., Erie, Pa. (A, B)
★Faeco Machine Co., Inc., Paterson, N. J. (B)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A, B)
★Fjellman American, Inc., Joliet, Ill. (A, B)
★French Oil Mill Machinery Co., The, Piqua, Ohio (A, B)
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill. (A, B)
★Hull-Standard Corp., Hatboro, Pa. (A)
Hunt, Rodney, Machine Co., Orange, Mass. (A)
Iddon Brothers Ltd., Leyland, Lancashire, England (B)
Identification Service Corp., New York 36, N. Y.
Inta Roto Machine Co., Richmond 3, Va. (A)

★ Indicates Advertiser

★Johnson Machinery Co., Newark 5, N. J. (A, B)
★Karlton Machinery Corp., Chicago 11, Ill. (A, B)
Lake Erie Machinery Corp., Buffalo, 17, N. Y. (A, B)
★Lawton, C. A., Co., The, DePere, Wis. (A, B)
Lembo Machine Works, Inc., Paterson 4, N. J. (B)
★Liberty Machine Co., Inc., Paterson 4, N. J. (A, B)
Lodge & Shipley Co., The, Cincinnati 25, Ohio (A, B)
★Logan Hydraulics, Inc., Chicago 30, Ill. (A, B)
Loomis Engineering & Mfg. Co., Caldwell, N. J. (A, B)
★M & N Hydraulic Press Co., Inc., Clifton, N. J. (A, B)
Machinery Factory & Foundry Ltd., Netsal, Switzerland (A)
Meiki Co., Ltd., Nagoya, Japan (A, B)
Monkley Corp., Worcester 8, Mass. (A, B)
Oliver Corp., The, A. B. Farquhar Div. York, Pa. (A, B)
Pasadena Hydraulics, Inc., El Monte, Calif. (A, B)
Plastic Laminating Corp., Vauxhall, N. J. (A, B)
Shannon, Alexander J., Co., The, New York 38, N. Y. (A, B)
G. Siempelkamp & Co., Krefeld, Germany (A, B)
Studebaker Hydraulic Products Co., Melrose Park, Ill. (A, B)
★Symons, Ralph B., Associates, Inc., Tiverton, R. I. (A, B)
Toko Machine Industry Co., Ltd., Tokyo, Japan (A, B)
★Triulzi, A. Off., s.a.s. Milan, Italy (A)
Union Tool Corp., The, Warsaw, Ind. (A)
Verson Allsteel Press Co., Chicago 19, Ill. (A, B)
★Watson-Stillman Press Div., Farrel-Birmingham Co., Inc., Rochester 10, N. Y. (B)
★Werner & Pfleiderer, Stuttgart, Germany (A, B)
★Williams-White & Co., Moline, Ill. (A)
★R. D. Wood Co., Philadelphia 5, Pa. (A, B)

LINERS, EXTRUDER CYLINDERS

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
Blaw-Knox Co., Pittsburgh 22, Pa.
★Davis-Standard Div., Franklin Research Corp., Mystic, Conn.
★Egan, Frank W., & Co., Somerville, N. J.
Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany
Hale & Kullgren, Inc., Akron, Ohio
★Industrial Research Laboratories, Div. of Honolulu Oil Corp., Los Angeles 11, Calif.
J M C Co., Newark 5, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Omni Products Corp., New York 16, N. Y.

LUBRICATING SYSTEMS, CENTRALIZED

Bijur Lubricating Corp., Rochelle Park, N. J.
Lincoln Engineering Co., St. Louis 20, Mo.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.

★ Indicates Advertiser

MARKING EQUIPMENT

A. Branding
B. Engraving
Printing (See Printing Presses for Plastics)
C. Roll Leaf Stamping

★Ackerman Gould Co., Oceanside, N. Y. (C)
★Acromark Co., The, Elizabeth 4, N. J. (A, B, C)
★Apex Machine Co., College Point 56, N. Y. (C)
Defiance Machine & Tool Co., St. Louis 10, Mo. (A, B, C)
Foredom Electric Co., Inc., Bethel, Conn. (B)
★Gane Bros. & Lane, Inc., Chicago 7, Ill. (C)
★Halvorfold Kwikprint Co., Jacksonville, Fla. (A, C)
Industrial Marking Equipment Co., Inc., Brooklyn 8, N. Y. (C)
★Kingsley Machines, Hollywood 38, Calif. (C)
Markem Machine Co., Keene, N. H. (C)
★Matthews, James H., & Co., Pittsburgh 13, Pa. (A, B, C)
★Mico Instrument Co., Cambridge 38, Mass. (B)
Monkley Corp., Worcester 8, Mass. (B)
★New Hermes Engraving Machine Corp., New York 11, N. Y. (B)
★Olsenmark Corp., New York 13, N. Y. (A, C)
★Omni Products Corp., New York 16, N. Y. (B, C)
★Peerless Roll Leaf Co. Inc., Union City, N. J. (C)
Pierce Wrapping Machine Co., La Grange Pk., Ill. (B)
★Preis, H. P., Engraving Machine Co., Hillside 5, N. J. (B)
Skyline Industries, Titusville, Pa. (A)
Superior Roll Leaf Mfrs., Inc., Hackensack, N. J. (C)
Swan Machine Co., New York 1, N. Y. (C)
Technicraft Co., Boston 34, Mass. (B)
★Weber Hot Stamping Equipment Co., Chicago 13, Ill. (C)
Weber Marking Systems, Inc., Mt. Prospect, Ill. (B)
Western Supplies Co., St. Louis 6, Mo. (B)

MASK WASHING MACHINES

★Conforming Matrix Corp., Toledo 2, Ohio
Cooper, D. C., Co., Chicago 5, Ill.
DeVilbiss Co., The, Toledo 1, Ohio
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
★Sepanski & Associates, Grand Rapids 5, Mich.
Sommer & Maca Glass Machinery Co., Chicago 50, Ill.

METAL DETECTORS AND SEPARATORS

Brilmayer, E. W., Laboratories, Inc., New York 38, N. Y.
Carpco Mfg., Inc., Jacksonville 6, Fla.
Crucible Steel Co. of America, Pittsburgh 30, Pa.
Industrial Plastics, Ltd., London W.1, England
Magnetic Engineering & Mfg. Co., Clifton, N. J.
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
Radio Corp. of America, Camden, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.

METAL SPRAYING MACHINES

★Binks Mfg. Co., Chicago 12, Ill.
Schori Process Corp., Long Island City 1, N. Y.

MILLS

A. 2-Roll
B. Fine Grinding

Abbe Engineering Co., New York 17, N. Y. (A, B)
★Abbé, Paul O., Inc., Little Falls, N. J. (B)
★Adamson United Co., Akron 4, Ohio (A)
★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio (A)
Albert, P. E., & Son, Trenton 5, N. J. (A)
Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. (A, B)
★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany (A)
Blaw-Knox Co., Pittsburgh 22, Pa. (A, B)
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio (A)
★Condux-Werk, Herbert A. Merges, K.G., Wolfgang/Hanau, West Germany (A, B)
Continental Machinery Co., Inc., New York 7, N. Y. (A, B)
Custom Machine & Design, Inc., Akron 9, Ohio (A)
Day, J. H., Co., The, Cincinnati 12, Ohio (A, B)
★Entoleter Div., Safety Industries, Inc., New Haven, Conn. (B)
★Erie Engine & Mfg. Co., Erie, Pa. (A)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A)
Fellner & Ziegler G.m.b.H., Frankfurt/Main, West Germany (B)
Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio (B)
First Machinery Corp., Brooklyn 15, N. Y. (A, B)
Gump, B. F., Co., Chicago 50, Ill. (A, B)
Hale & Kullgren, Inc., Akron, Ohio (A)
Iddon Brothers Ltd., Leyland, Lancashire, England (A, B)
J M C Co., Newark 5, N. J. (A)
★Johnson Machinery Co., Newark 5, N. J. (A)
★Kleinewefers, Joh., Söhne, Krefeld, West Germany (A, B)
Miller, Franklin P., & Son, East Orange 16, N. J. (A, B)
★Negri Bossi & Co., Milan, Italy (B)
Patterson Foundry and Machine Co., The, E. Liverpool, Ohio (B)
Pulva Corp., Perth Amboy, N. J. (B)
Pulverizing Machinery Div., Metals Disintegrating Co., Inc., Summit, N. J. (B)
★Rainville Co, Inc., The, Garden City, N. Y. (B)
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J. (A)
Ross, Charles, & Son Co., Brooklyn 5, N. Y. (A, B)
★Shaw, Francis, & Co., Ltd., Manchester 11, England (A, B)
Sherman Rubber Co., Div. of Botwinik Bros., Inc., Worcester, Mass. (A)
Sprout, Waldron & Co., Inc., Muncy, Pa. (A, B)
Sturtevant Mill Co., Boston 22, Mass. (A, B)
★Symons, Ralph B., Associates, Inc., Tiverton, R. I. (A)
★Thropp, Wm. R., & Sons, Div. of J. M. Lehmann Co., Inc., Lyndhurst, N. J. (A)
Toko Machine Industry Co., Ltd., Tokyo, Japan (A, B)
Troester, Paul, Maschinenfabrik, Hannover-Wulfel, West Germany (A)

MIXERS

A. *Intensive Internal*
B. *Dry Coloring and Blending*
C. *Liquid*

Abbe Engineering Co., New York 17, N. Y. (A, B)
★Abbé, Paul O., Inc., Little Falls, N. J. (B)
★Adamson United Co., Akron 4, Ohio (A)
Alsop Engineering Corp., Milldale, Conn. (C)
Baker Perkins, Inc., Saginaw, Mich. (A)
Blaw-Knox Co., Pittsburgh 22, Pa. (A, B)
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio (A)
Buflovak Equipment Div., Blaw-Knox Co., Buffalo 11, N. Y. (C)
Buss, Ltd., Basel, Switzerland (A)
Chemineer, Inc., Dayton 2, Ohio (C)
Cleveland Mixer Co., Bedford Heights, Cleveland, Ohio (C)
Colton, Arthur, Co., Div. of Snyder Corp., Detroit 7, Mich. (B, C)
Continental Machinery Co., Inc., New York 7, N. Y. (A)
Cooper, D. C., Co., Chicago 5, Ill. (B)
Crown Machinery, Inc., Los Angeles 11, Calif. (B)
Custom Machine & Design, Inc., Akron 9, Ohio (A)
★Dake Corp., Grand Haven, Mich. (B)
Day, J. H., Co., The, Cincinnati 12, Ohio (A, B)
Devine, J. P., Mfg. Co., Pittsburgh 1, Pa. (B, C)
★Dunning & Boschert Press Co., Inc., The, Syracuse, N. Y. (B)
Eastern Industries, E. Norwalk, Conn. (C)
★Entoleter Div., Safety Industries, Inc., New Haven, Conn. (A, B)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A)
Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio (B)
First Machinery Corp., Brooklyn 15, N. Y. (A, B)
★Henschel-Werke Gmbh, Kassel, West Germany (A, B)
★Hull Corp., Hatboro, Pa.
Industrial Plastics, Ltd., London W.1, England (A, B)
★Injection Molders Supply Co., Cleveland 20, Ohio (B)
International Engineering, Inc., Dayton 1, Ohio (C)
★Johnson Machinery Co., Newark 5, N. J. (A, B)
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y. (B)
Manning & Lewis Engineering Co., Newark 4, N. J. (C)
Manton-Gaulin Mfg. Co., Inc., Everett 49, Mass. (A)
Miller, Franklin P., & Son, East Orange 16, N. J. (A, B)
Mixing Equipment Co., Inc., Rochester 1, N. Y. (C)
New England Tank & Tower Co., Everett 49, Mass. (C)
Patterson Foundry and Machine Co., The, E. Liverpool, Ohio (A, B)
Patterson-Kelley Co. Inc., The, E. Stroudsburg, Pa. (A, B)
★Prodex Corp., Fords, N. J. (A, B)
★Progressive Machine Co., Inc., Paterson 4, N. J. (A)
★Rainville Co., Inc., The, Garden City, N. Y. (B)
Read Standard, Div. of Capitol Products Corp., York, Pa. (A, B)
★Reed Plastics Corp., Worcester 8, Mass. (A, B)
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J. (B)
Ross, Charles, & Son Co., Brooklyn 5, N. Y. (A, B)
★Shaw, Francis, & Co., Ltd., Manchester 11, England (A, B)
Sprout, Waldron & Co., Inc., Muncy, Pa. (B)
Standard Electric Mfg. Co., West Berlin, N. J.
Stevenson Co., The, Wellsville, Ohio (C)
Struthers Wells Corp., Warren, Pa. (C)
Sturtevant Mill Co., Boston 22, Mass. (B)
Toko Machine Industry Co., Ltd., Tokyo, Japan (A)
★Werner & Pfleiderer, Stuttgart, West Germany (A, B, C)
Young Machinery Co., Inc., The, Muncy, Pa. (B)

MOLD CHILLERS

Al-Be Industries, South Gate, Calif.
Anson Tools & Gages, Inc., Erie, Pa.
Artisan Metal Products, Inc., Waltham 54, Mass.
Blaw-Knox Co., Pittsburgh 22, Pa.
Dean Thermo-Panel Coil Div., Dean Products, Inc., Brooklyn 38, N. Y.
★Egan, Frank W., & Co., Somerville, N. J.
Electric Trading Co., New York 13, N. Y.
General Engineering Co., Radcliffe, Lancs., England
Gerin Mfg. Co., Inc., Newark 7, N. J.
Goulding Mfg. Co., Saginaw, Mich.
★Industrial Ovens, Inc., Cleveland 11, Ohio
★Injection Molders Supply Co., Cleveland 20, Ohio
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
L & P Tool Co., Cincinnati 25, Ohio
Lavorasione Materie Plastiche, S.A.S., Torino, Italy
Lembo Machine Works, Inc., Paterson 4, N. J.
★Liberty Machine Co., Inc., Paterson 4, N. J.
★Mayer Refrigerating Engineers, Lincoln Park, N. J.
Mercury Industries, Inc., Hillsdale, N. J.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.
★Modern Plastic Machinery Corp., Lodi, N. J.
Motch & Merryweather Machinery Co., Cleveland 17, Ohio
★National Rubber Machinery Co., Akron 8, Ohio
★Omni Products Corp., New York 16, N. Y.
★Pecorp, Inc., Wilmington 4, Del.
★Rainville Co., Inc., The, Garden City, N. Y.
★Saren, Inc., Chicago 51, Ill.
Shriver, T., & Co., Inc., Harrison, N. J.
★Sterling, Inc., Milwaukee 18, Wis.
Tenney Engineering, Inc., Union, N. J.
Verduin, John, Machine Corp., Paterson 4, N. J.
Vic Mfg. Co., Minneapolis, Minn.
★Waldron, John, Corp., New Brunswick, N. J.
Wilkinson Co., Akron 10, Ohio

MOLD COMPONENTS, STANDARD STOCK

Crucible Steel Co. of America, Pittsburgh 30, Pa.
Damen Tool & Engineering Co., Inc., Chicago 31, Ill.
★Detroit Mold Engineering Co., Detroit, Mich.
★National Tool & Mfg. Co., Kenilworth, N. J.
★Omni Products Corp., New York 16, N. Y.
★Van Dorn Iron Works Co., The, Cleveland 4, Ohio

MOLDS AND DIES

(See Specialized Services, p. 1141)

MOTORS

Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
★General Electric Co., Apparatus Sales Div., Schenectady 5, N. Y.
Induction Motors Corp., Westbury, N. Y.
★Modern Plastic Machinery Corp., Lodi, N. J.
Oilgear Co., The, Milwaukee 4, Wis.
★Reliance Electric & Engineering Co., Cleveland 17, Ohio
Sterling Electric Motors, Inc., Los Angeles 22, Calif.

NOZZLES FOR INJECTION MOLDING MACHINES

Anson Tools & Gages, Inc., Erie, Pa.
Blaw-Knox Co., Pittsburgh 22, Pa.
Brush Beryllium Co., The, Cleveland 3, Ohio
★Clifton Hydraulic Press Co., Clifton, N. J.
★Injection Molders Supply Co., Cleveland 20, Ohio
Melt Extractor Mfg. Corp., New York 67, N. Y.
★Omni Products Corp., New York, N. Y.
★Peco Machinery Sales (Westminster), Ltd., London, S.W.1, England
Rainco Mfg., Inc., Franklin, Pa.
★Standard Tool Co., Leominster, Mass.

OVENS

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
American Instrument Co., Inc., Silver Spring, Md.
★Binks Mfg. Co., Chicago 12, Ill.
Blaw-Knox Co., Pittsburgh 22, Pa.
★Blue, E. B., Co., S. Norwalk, Conn.
Brenner, I. G., Co., Newark, Ohio
★Brosites Machine Co., Inc., New York 7, N. Y.
Calmic Engineering Co., Ltd., Crewe, England
Colton, Arthur, Co., Div. of Snyder Corp., Detroit 7, Mich.
Continental Machinery Co., Inc., New York 7, N. Y.
Cooper, D. C., Co., Chicago 5, Ill.
Dawson, F. C., Engineering Co., Canton, Mass.
DeVilbiss Co., The, Toledo 1, Ohio
Devine, J. P., Mfg. Co., Pittsburgh, Pa.
Dornbusch & Co., Krefeld, West Germany
Drying Systems Co., Chicago 40, Ill.
Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio
Fisher Scientific Co., Pittsburgh 19, Pa.
General Engineering Co., Radcliffe, Lancs., England
Grieve-Hendry Co., Inc., Chicago, Ill.
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y.
Hedin, Ltd., London E. 18, England
Herbert Products, Inc., Woodhaven 21, N. Y.

★ Indicates Advertiser

★Industrial Ovens Inc., Cleveland 11, Ohio
★Injection Molders Supply Co., Cleveland 20, Ohio
Inta Roto Machine Co., Richmond 3, Va.
★Johnson Machinery Co., Newark 5, N. J.
Leon Machine & Engineering Co., Riverside, N. J.
★Litzler, C. A., Co., Inc., Cleveland 9, Ohio
★Lydon Bros., Inc., Hackensack, N. J.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.
Michigan Oven Co., Detroit 1, Mich.
Miskella Infra-Red Co., Inc., The, Cleveland 4, Ohio
★Modern Plastic Machinery Corp., Lodi, N. J.
Radiant Heat Enterprises, Inc., Short Hills, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
Randall Mfg. Co., Inc., New York 59, N. Y.
Ransohoff Co., Hamilton, Ohio
Rockwell, W. S., Co., Fairfield, Conn.
Tenney Engineering, Inc., Union, N. J.
Whitaker, Douglas C., Co., Glenside, Pa.
Young Bros. Co., Cleveland 13, Ohio.

PAINTING EQUIPMENT

★Binks Mfg. Co., Chicago 12, Ill.
★Conforming Matrix Corp., Toledo 2, Ohio
DeVilbiss Co., The, Toledo 1, Ohio
Electric Trading Co., New York 13, N. Y.
★Finish Engineering Co., Inc., Erie, Pa.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.
★Sepanski & Associates, Grand Rapids 5, Mich.
Whitaker, Douglas C., Co., Glenside, Pa.

PAINT WIPING MACHINES

★Finish Engineering Co., Inc., Erie, Pa.

PELLETIZERS

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
Al-Be Industries, South Gate, Calif.
Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England
Baker Perkins, Inc., Saginaw, Mich.
★Ball & Jewell, Inc., Brooklyn 22, N. Y.
★Bonnot Co., The, Canton 2, Ohio
Bradley & Turton, Ltd., Kidderminster, England
Buss, Ltd., Basel, Switzerland
Colton, Arthur, Co., Div. of Snyder Corp., Detroit 7, Mich.
★Condux-Werk, Herbert A. Merges, K.G., Wolfgang/Hanau, West Germany
★Covema s.r.l., Milan, Italy
★Cumberland Engineering Co., Inc., Providence 1, R. I.
★Davis-Standard Div., Franklin Research Corp., Mystic, Conn.
★Entoleter Div., Safety Industries, Inc., New Haven, Conn.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
Fellner & Ziegler G.m.b.H., Frankfurt/Main, West Germany
First Machinery Corp., Brooklyn 15, N. Y.

Hale & Kullgren, Inc., Akron, Ohio
★Hartig Extruders Div., Midland-Ross Corp., Mountainside, N. J.
Industrial Plastics, Ltd., London W.1, England
J M C Co., Newark 5, N. J.
★Johnson Machinery Co., Newark, N. J.
L & P Tool Co., Cincinnati 25, Ohio
Lavorazione Materie Plastiche, S.A.S., Torino, Italy
Miller, Franklin P., & Son, East Orange 16, N. J.
Mitts & Merrill, Saginaw Mich.
★Modern Plastic Machinery Corp., Lodi, N. J.
★Negri Bossi & Co., Milan, Italy
★Omni Products Corp., New York, N. Y.
★Rainville Co., Inc., The, Garden City, N. Y.
Sprout, Waldron & Co., Inc., Muncy, Pa.
★Sterling Extruder Corp., Linden, N. J.
★Stokes, F. J., Corp., Philadelphia 20, Pa.
★Taylor, Stiles & Co., Riegelsville, N. J.
★Windsor, R. H., Ltd., Chessington, England

PERFORATING MACHINES

★Ackerman Gould Co., Oceanside, N. Y.
★Atlas Vac-Machine Corp., Rochester 21, N. Y.
Chemicraft Corp., New York 1, N. Y.
★Dusenbery, John, Co., Verona, N. J.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
Ketchpel Engineering Co., W. Englewood, N. J.
Main, Robert A., & Sons, Inc., Paramus, N. J.
★Perforated Specialties Co., New York 1, N. Y.
Swan Machine Co., New York 1, N. Y.
Western Supplies Co., St. Louis 6, Mo.

PIPE WRAPPING MACHINES

Iddon Brothers Ltd., Leyland, Lancashire, England
Terkelsen Machine Co., Boston, Mass.

PLATENS, PRESS
(Electric and Steam)

★Adamson United Co., Akron 4, Ohio
Albert, P. E., & Son, Trenton 5, N. J.
Atlantic Mfg. Co., Philadelphia 22, Pa.
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa.
Berthelsen Engineering, Joliet, Ill.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Bliss, E. W., Co., Canton 10, Ohio
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio
Bradley & Turton, Ltd., Kidderminster, England
★Carver, Fred S., Inc., Summit, N. J.
★Clifton Hydraulic Press Co., Clifton, N. J.
★Covema s.r.l., Milan, Italy
★Custom Engineering Co., Erie, Pa.
★Dake Corp., Grand Haven, Mich.
★Daniels Ltd., T. H. & J., Stroud, Gloucestershire, England
★Dunning & Boschert Press Co., Inc., The, Syracuse 2, N. Y.
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio
★Erie Engine & Mfg. Co., Erie, Pa.
Falcon Equipment Co., New Brighton, Pa.
★French Oil Mill Machinery Co., The, Piqua, Ohio

★Johnson Machinery Co., Newark, N. J.
★Karlton Machinery Corp., Chicago, Ill.
Lake Erie Machinery Corp., Buffalo 17, N. Y.
★Lawton, C. A., Co., The, DePere, Wis.
Lempco Industrial, Inc., Bedford, Ohio
Lodge & Shipley Co., The, Cincinnati 25, Ohio
★Logan Hydraulics, Inc., Chicago 30, Ill.
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
Plastic Laminating Corp., Vauxhall, N. J.
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.
★Roehlen Engraving Works, Rochester 5, N. Y.
★Shaw, Francis, & Co., Ltd., Manchester 11, England
G. Siempelkamp & Co., Krefeld, Germany
★Symons, Ralph B., Associates, Inc., Tiverton, R. I.
★Thermel, Inc., Franklin Park, Ill.
Verduin, John, Machine Corp., Paterson 4, N. J.
★Werner & Pfleiderer, Stuttgart, West Germany
Willson Camera Co., Havertown, Pa.
★Wood, R. D., Co., Philadelphia 5, Pa.

PLATES FOR COMPRESSION MOLDING

Albert, P. E., & Son, Trenton 5, N. J.
Atlantic Mfg. Co., Philadelphia 22, Pa.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
★Clifton Hydraulic Press Co., Clifton, N. J.
Fabrite Metals Corp., Brooklyn 27, N. Y.
★French Oil Mill Machinery Co., The, Piqua, Ohio
★Johnson Machinery Co., Newark 5, N. J.
Payne Tool & Engineering Co., The, Springfield, Ohio

POLISHING MACHINES

Boice-Crane Co., Toledo 6, Ohio
Clair Mfg. Co., Inc., Olean, N. Y.
Foredom Electric Co., Inc., Bethel, Conn.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Merit Products, Inc., Los Angeles 16, Calif.
★Mico Instrument Co., Cambridge, Mass.
Sommer & Maca Glass Machinery Co., Chicago 50, Ill.
★Waldron, John, Corp., New Brunswick, N. J.

POLYETHYLENE TREATERS FOR PRINTING

★Aetna Electronics Corp., North Branch, N. J.
Al-Be Industries, South Gate, Calif.
Barker-Davis Machine Co., Inc., Leominster, Mass.
Industrial Plastics, Ltd., London W.1, England
Miskella Infra-Red Co., Inc., The, Cleveland 4, Ohio
★Modern Plastic Machinery Corp., Lodi, N. J.
★Omni Products Corp., New York 16, N. Y.
Reeve Electronics, Inc., Chicago 6, Ill.
★Waldron, John, Corp., New Brunswick, N. J.

★ Indicates Advertiser

POWER UNITS, HYDRAULIC

Albert, P. E., & Son, Trenton 5, N. J.
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa.
Berthelsen Engineering, Joliet, Ill.
★Clifton Hydraulic Press Co., Clifton, N. J.
★Consolidated Baling Machine Co., Brooklyn 15, N. Y.
Custom Machine & Design, Inc., Akron 9, Ohio
★Dake Corp., Grand Haven, Mich.
★Dusenbery, John, Co., Verona, N. J.
★Erie Engine & Mfg. Co., Erie, Pa.
★French Oil Mill Machinery Co., The, Piqua, Ohio
GPE Controls, Inc., Chicago 11, Ill.
★Goulding Mfg. Co., Saginaw, Mich.
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill.
★Hull-Standard Corp., Hatboro, Pa.
★Hydraulic Press Mfg. Co., The, A Div. of Koehring Co., Mount Gilead, Ohio
★Johnson Machinery Co., Newark 5, N. J.
Kabar Mfg. Corp., New York 62, N. Y.
★Karlton Machinery Corp., Chicago 11, Ill.
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
Oilgear Co., The, Milwaukee 14, Wis.
Racine Hydraulics & Machinery, Inc., Racine, Wis.
Rodgers Hydraulic, Inc., Minneapolis 26, Minn.
G. Siempelkamp & Co., Krefeld, Germany
★Werner & Pfleiderer, Stuttgart, West Germany
★Wood, R. D., Co., Philadelphia 5, Pa.

PREFORMERS

A. *Fibrous Glass*
B. *Other Fibrous Materials*
C. *Granular or Powder Materials*

★Aust & Schüttler u. Co., Düsseldorf, West Germany (A)
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England (A, C)
★Bonnot, Co., The, Canton 2, Ohio (A, B, C)
Bradley & Turton, Ltd., Kidderminster, England (C)
Brenner, I. G., Co., Newark, Ohio (A)
Colton, Arthur, Co., Div. of Snyder Corp., Detroit 7, Mich. (C)
★Daniels, T. H. & J., Ltd., Stroud, Gloucestershire, England (C)
★Erie Engine & Mfg. Co., Erie, Pa. (A)
Finn & Fram, Sunland, Calif. (A)
★Lawton, C. A., Co., The, DePere, Wis. (A)
★Logan Hydraulics, Inc., Chicago 30, Ill. (A, B, C)
★Omni Products Corp., New York 16, N. Y. (A)
★Stokes, F. J., Corp., Philadelphia 20, Pa. (C)
★Symons, Ralph B., Associates, Inc., Tiverton, R. I. (A, B, C)
Turner Machine Co., Inc., Danbury, Conn. (A, B)

PREPLASTICIZING UNITS

★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany
★Bonnot Co., The, Canton 2, Ohio
Buss, Ltd., Basel, Switzerland
Crown Machine & Tool Co., Fort Worth 7, Texas
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
★Hydraulic Press Mfg. Co., The, A Div. of Koehring Co., Mount Gilead, Ohio
Industrial Plastics, Ltd., London W.1, England
★Johnson Machinery Co., Newark 5, N. J.
Machinery Factory & Foundry Ltd., Netsal, Switzerland
Melt Extractor Mfg. Corp., New York 67, N. Y.
★Moslo Machinery Co., Cleveland 15, Ohio
★Omni Products Corp., New York 16, N. Y.
★Peco Machinery Sales (Westminster), Ltd., London, S.W.1, England
Radio Heaters, Ltd., Wokingham, Berks, England
★Rainville Co., Inc., The, Garden City, N. Y.
★Triulzi, A. Off., s.a.s. Milan, Italy
★Watson-Stillman Press Div., Farrel-Birmingham Co., Inc., Rochester 10, N. Y.

PRESS POLISHING MACHINES

★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio
★Clifton Hydraulic Press Co., Clifton, N. J.
★Erie Engine & Mfg. Co., Erie, Pa.
★French Oil Mill Machinery Co., The, Piqua, Ohio
★Karlton Machinery Corp., Chicago 11, Ill.
G. Siempelkamp & Co., Krefeld, Germany

PRINTING PRESSES

A. *Flexographic*
B. *Offset*
C. *Screen Printing Machines*
D. *Miscellaneous*

★Acromark Co., The, Elizabeth 4, N. J. (D)
★Apex Machine Co., College Point 56, N. Y. (D)
★Black-Clawson Co., The, Dilts Div., Fulton, N. Y. (A, D)
Conapac Corp., New York 3, N. Y. (A)
★Cosom Engineering Corp., Minneapolis 16, Minn. (D)
Defiance Machine & Tool Co., St. Louis 10, Mo. (D)
Dependable Compressor & Machine Co., Inc., New York 11, N. Y. (C)
Dornbusch & Co., Krefeld, West Germany (D)
★Faeco Machine Co., Inc., Paterson, N. J. (A)
G & S Label Corp., New York 1, N. Y. (D)
General Engineering Co., Radcliffe, Lancs., England (D)
General Research & Supply Co., Grand Rapids 3, Mich. (C)
★Hamac Packmaschinen GmbH, Dusseldorf, West Germany (A)
Hamilton Tool Co., The, Hamilton, Ohio (A, B, D)
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp. (A)
Inta Roto Machine Co., Richmond 3, Va. (A, D)
International Eastern Co., New York 1, N. Y. (B, D)
Lawson Printing Machine Co., St. Louis 8, Mo. (C)
Lee Machinery Corp., New York 10, N. Y. (A)
Lembo Machine Works, Inc., Paterson 4, N. J. (A, D)
★Liberty Machine Co., Inc., Paterson 4, N. J. (A, D)
Markem Machine Co., Keene, N. H. (A, B, C)
Miehle Co., The, Div. of Miehle-Goss-Dexter, Inc., Chicago 8, Ill. (B, D)
Monkley Corp., Worcester 8, Mass. (A)
★Olsenmark Corp., New York 13, N. Y. (D)
★Omni Products Corp., New York 16, N. Y.
Pierce Wrapping Machine Co., La Grange Pk. (Chicago Suburb), Ill. (D)
★Rainville Co., Inc., The, Garden City, N. Y. (A, B)
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany (A)
Rutherford Machinery Co., Div. of Sun Chemical Corp., E. Rutherford, N. J. (B)
Shannon, Alexander J., Co., The, New York 38, N. Y. (A, B, D)
(A, B, D)
Skyline Industries, Titusville, Pa. (B)
Swan Machine Co., New York 1, N. Y. (A)
Thomson-National Press Co., Franklin, Mass. (A, D)
Toko Machine Industry Co., Ltd., Tokyo, Japan (A, B, D)
★Waldron, John, Corp., New Brunswick, N. J. (A, B, D)
Web Controls Corp., W. Englewood, N. J. (A)
Weber Marking Systems, Inc., Mt. Prospect, Ill. (D)
Albert Weiss & Co., Brooklyn 32, N. Y. (A)

PROPORTIONING AND METERING SYSTEMS

★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
★Automatic Process Control, Union, N. J.
B. B. Chemical Co., Cambridge 39, Mass.
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa.
Buss, Ltd., Basel, Switzerland
★Dayton Rubber Co., The, Dayton, Ohio
Mateer, G. Diehl, Co., Wayne, Pa.
Delsen Corp., Glendale 4, Calif.
Exact Weight Scale Co., Columbus 15, Ohio
GPE Controls, Inc., Chicago 11, Ill.
Gump, B. F., Co., Chicago 50, Ill.
Gusmer, A., Inc., Woodbridge, N. J.
Hardman, H. V., Co., Inc., Belleville 9, N. J.
★Hull Corp., Hatboro, Pa.
Jennings Engineering Co., Philadelphia 4, Pa.
Magnolia Plastics, Inc., Chamblee, Ga.
Mercury Industries, Inc., Hillsdale, N. J.
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
Richardson Scale Co., Clifton, N. J.
Wallace & Tiernan, Inc., Belleville 9, N. J.
Weighing & Control Components, Inc., Hatboro, Pa.
Albert Weiss & Co., Brooklyn 22, N. Y.
★Werner & Pfleiderer, Stuttgart, Germany
Zenith Products Co., W. Newton 65, Mass.

★ Indicates Advertiser

PULVERIZING MACHINES

★Abbé, Paul O., Inc., Little Falls, N. J.
American Pulverizer Co., St. Louis 10, Mo.
★Condux-Werk, Herbert A. Merges, K.G., Wolfgang/Hanau, West Germany
Custom Machine & Design, Inc., Akron 9, Ohio
★Entoleter Div., Safety Industries, Inc., New Haven, Conn.
Fellner & Ziegler G.m.b.H., Frankfurt/Main, West Germany
★Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio
First Machinery Corp., Brooklyn 15, N. Y.
Industrial Plastics, Ltd., London W.1, England
★Johnson Machinery Co., Newark 5, N. J.
Miller, Franklin P., & Son, East Orange 16, N. J.
Munson Mill Machinery Co., Utica 1, N. Y.
Pulva Corp., Perth Amboy, N. J.
Pulverizing Machinery Div., Metals Disintegrating Co., Inc., Summit, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
Ross, Charles & Son Co., Brooklyn 5, N. Y.
Sturtevant Mill Co., Boston 22, Mass.

PUMPS

A. Coolant
B. Hydraulic
C. Vacuum

Abbe Engineering Co., New York 17, N. Y. (C)
Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. (A, B, C)
American Instrument Co., Inc., Silver Spring, Md. (A, C)
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa. (B)
Berthelsen Engineering, Joliet, Ill. (B)
Bradley & Turton, Ltd., Kidderminster, England (B)
Calmic Engineering Co., Ltd., Crewe, England (C)
Central Scientific Co., Chicago 13, Ill. (C)
★Consolidated Electrodynamics Corp., Rochester Div., Rochester 3, N. Y. (C)
★Covema s.r.l., Milan, Italy (B)
Devine, J. P., Mfg. Co., Pittsburgh 1, Pa. (C)
★Dusenbery, John, Co., Verona, N. J. (B)
Edwards High Vacuum, Inc., Niagara Falls, N. Y. (C)
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio (B)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (B)
First Machinery Corp., Brooklyn 15, N. Y. (C)
Fisher Scientific Co., Pittsburgh 19, Pa. (C)
★French Oil Mill Machinery Co., The, Piqua, Ohio (B)
High Vacuum Equipment Corp., Hingham, Mass. (C)
★Hydraulic Press Mfg. Co., The, A. Div. of Koehring Co., Mount Gilead, Ohio (B)
★Johnson Machinery Co., Newark 5, N. J. (B)
Leiman Bros., Inc., Newark 1, N. J. (C)
Lincoln Engineering Co., St. Louis 20, Mo. (B)
Machinery Factory & Foundry Ltd., Netstal, Switzerland (B)
Manton-Gaulin Mfg. Co., Inc., Everett 49, Mass. (A, B)
★Mercury Molding Machinery, Inc., Yonkers, N. Y. (C)
★NRC Equipment Corp., Newton 61, Mass. (C)
Nash Engineering Co., The, S. Norwalk, Conn. (C)
Oilgear Co., The, Milwaukee 4, Wis. (B)
Pennsylvania Pump & Compressor Co., Easton, Pa. (A, C)
Quincy Compressor Co., Quincy, Ill. (C)
Racine Hydraulic & Machinery, Inc., Racine, Wis. (B)
Standard Electric Mfg. Co., W. Berlin, N. J. (A)
★Stokes, F. J., Corp., Philadelphia 20, Penna. (C)
★Symons, Ralph B., Associates, Inc., Tiverton, R. I. (B)
★Triulzi, A. Off., s.a.s. Milan, Italy (B)
★Wallace & Tiernan, Inc., Belleville 9, N. J. (B)
★Werner & Pfleiderer, Stuttgart, West Germany (B)
Worthington Corp., Harrison, N. J. (B, C)

PUNCH PRESSES

Allen, Alva, Industries, Clinton, Mo.
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa.
Bliss, E. W., Co., Canton 10, Ohio
Clearing Div. of U.S. Industries, Inc., Chicago 38, Ill.
Cooper, D. C., Co., Chicago 5, Ill.
Emhart Mfg. Co., Hudson, N. Y.
Emhart Mfg. Co., Portland Div., Portland, Conn.
★Famco Machine Co., Kenosha, Wis.
Lempco Industrial, Inc., Bedford, Ohio
Portz Plastics & Fibre Co., Milwaukee 3, Wis.
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass.
★Triulzi, A. Off., s.a.s. Milan, Italy
Verson Allsteel Press Co., Chicago 19, Ill.
★Williams-White & Co., Moline, Ill.

PYROMETERS

(See Instruments, p. 1132)

REWINDING EQUIPMENT

Al-Be Industries, South Gate, Calif.
★Associated Equipment Corp., Bellevue, Wash.
★Black-Clawson, Co., The, Dilts Div., Fulton, N. Y.
Dornbusch & Co., Krefeld, West Germany
★Dusenbery, John, Co., Verona, N. J.
Emery, Vern, Co., Sun Valley, Calif.
Entwistle Mfg. Corp., Providence 7, R. I.
★Faeco Machine Co., Inc., Paterson, N. J.
G & S Label Corp., New York 1, N. Y.
General Engineering Co., Radcliffe, Lancs., England
★Goulding Mfg. Co., Saginaw, Mich.
★Hobbs Mfg. Co., Worcester 5, Mass.
★Industrial Ovens Inc., Cleveland 11, Ohio
Industrial Plastics, Ltd., London W.1, England
Inta Roto Machine Co., Richmond 3, Va.
Johnstone Engineering & Machine Co., Atglen, Pa.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
Lee Machinery Corp., New York 10, N. Y.
Lembo Machine Works, Inc., Paterson 4, N. J.
★Liberty Machine Co., Inc., Paterson 4, N. J.
★Litzler, C. A., Co., Inc., Cleveland, Ohio
Monkley Corp., Worcester 8, Mass.
Mount Hope Machinery Co., Taunton, Mass.
★Omni Products Corp., New York 16, N. Y.
Photobell Co., Inc., New York 7, N. Y.
Proctor & Schwartz, Inc., Philadelphia 20, Pa.
★Progressive Machine Co., Inc., Paterson 4, N. J.
Rotobond Co., Bound Brook, N. J.
Ruf Machine Co., Inc., New York 28, N. Y.
Sealol Corp., Providence 5, R. I.
Shannon, Alexander J., Co., The, New York 38, N. Y.
Stanford Engineering Co., Salem, Ill.
Verduin, John, Machine Corp., Paterson 4, N. J.
★Waldron, John, Corp., New Brunswick, N. J.
Wallace, L. R., & Co., Pasadena 1, Calif.
Web Controls Corp., W. Englewood, N. J.

ROLL LEAF AND HOT STAMPING PRESSES

★Ackerman Gould Co., Oceanside, N. Y.
★Acromark Co., The, Elizabeth 4, N. J.
Admiral Coated Plastics, Inc., Hackensack, N. J.
★Apex Machine Co., College Point 56, N. Y.
Defiance Machine & Tool Co., St. Louis, 10, Mo.
G & S Label Corp., New York 1, N. Y.
★Gane Bros. & Lane, Inc., Chicago 7, Ill.
Griffin, Campbell, Hayes, Walsh, Inc., New York 10, N. Y.
Industrial Marking Equipment Co., Inc., Brooklyn 8, N. Y.
★Kingsley Machines, Hollywood 38, Calif.
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
Markem Machine Co., Keene, N. H.
★Matthews, James H., & Co. Pittsburgh 13, Pa.
★Olsenmark Corp., New York 13, N. Y.
★Omni Products Corp., New York 16, N. Y.
★Peerless Roll Leaf Co. Inc., Union City, N. J.
Rainbow Plastic Products, Inc., Minneapolis 16, Minn.
Superior Roll Leaf Mfrs., Inc., Hackensack, N. J.
Swan Machine Co., New York 1, N. Y.
Thomson-National Press Co., Franklin, Mass.
Timadco, Inc., Mineola, N. Y.
★Weber Hot Stamping Equipment Co., Chicago 13, Ill.

ROLLS

A. Calendering and Compounding
B. Embossing
C. Printing

★Ackerman Gould Co., Oceanside, N. Y. (B)
★Acromark Co., The, Elizabeth 4, N. J. (C)
★Adamson United Co., Akron 4, Ohio (A)

★ Indicates Advertiser

Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. (A)
American Engraving & Machine Co., Elizabeth, N. J. (B, C)
★Apex Machine Co., College Point 56, N. Y. (B, C)
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio (A)
Continental Machinery Co., Inc., New York 7, N. Y. (A)
Cylinder Mfg. Co., Hawthorne, N. J. (A)
Defiance Machine & Tool Co., St. Louis 10, Mo. (B, C)
Dornbusch & Co., Krefeld, West Germany (B)
★Faeco Machine Co., Inc., Paterson, N. J. (B, C)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A)
G & S Label Corp., New York 1, N. Y. (B, C)
Hunt, Rodney, Machine Co., Orange, Mass. (A)
Industrial Marking Equipment Co., Inc., Brooklyn 8, N. Y. (C)
Inta Roto Machine Co., Richmond 3, Va. (C)
International Engraving Corp., Cedar Grove, N. J. (A, B, C)
★Johnson Machinery Co., Newark 5, N. J. (A)
★Kleinewefers, Joh., Söhne, Krefeld, West Germany (A, B)
Lembo Machine Works, Inc., Paterson 4, N. J. (B, C)
Miller, Franklin P., & Son, East Orange 16, N. J. (A)
Pamarco, Inc., Roselle, N. J. (A, B, C)
Proctor & Schwartz, Inc., Philadelphia 20, Pa. (A)
★Progressive Machine Co., Inc., Paterson 4, N. J. (B)
★Robbins Plastic Machinery Corp., Elkhart, Ind. (B)
★Roehlen Engraving Works, Rochester 5, N. Y. (B)
Shannon, Alexander J., Co., The, New York 38, N. Y. (B, C)
★Shaw, Francis & Co., Ltd., Manchester 11, England (A)
Swan Machine Co., New York 1, N. Y. (A, B, C)
Toko Machine Industry Co., Ltd., Tokyo, Japan (A, B, C)
Tower Iron Works, Inc., Providence 1, R. I. (A)
Tyer Rubber Co., Andover, Mass. (A, B, C)
Union Tool Corp., The, Warsaw, Ind. (A)
Verduin, John, Machine Corp., Paterson 4, N. J. (A, B, C)

ROTARY FINISHING MACHINES

★Binks Mfg. Co., Chicago 12, Ill.
★Buss Machine Works, Inc., Holland, Mich.
Dornbusch & Co., Krefeld, West Germany
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Liberty Machine Co., Inc., Paterson 4, N. J.
Morse Mfg. Co., Inc., E. Syracuse, N. Y.
Nash, J. M., Co. Inc., Milwaukee 45, Wis.
Ransohoff Co., Hamilton, Ohio
Techline Div., Wheelabrator Corp., Vicksburg, Mich.

ROTATIONAL CASTING MACHINES

★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
★Akron Preform Mold Co., The, Cuyahoga Falls, Ohio
Blaw-Knox Co., Pittsburgh 22, Pa.
★Blue, E. B., Co., S. Norwalk, Conn.
Continental Machinery Co., Inc., New York 7, N. Y.
Hale & Kullgren, Inc., Akron, Ohio
★Mercury Molding Machinery, Inc., Yonkers, N. Y.

SCALES

(See Instruments, p. 1132)

SCREENING, SEPARATING, AND SIFTING MACHINES

Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
Carpco Mfg., Inc., Jacksonville 6, Fla.
Colton, Arthur, Co., Div. of Snyder Corp., Detroit 7, Mich.
★Condux-Werk, Herbert A. Merges, K.G., Wolfgang/Hanau, West Germany
Day, J. H., Co., The, Cincinnati 12, Ohio
★Entoleter Div., Safety Industries, Inc., New Haven, Conn.
Fellner & Ziegler G.m.b.H., Frankfurt/Main, West Germany
Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio
First Machinery Corp., Brooklyn 15, N. Y.
Gump, B. F., Co., Chicago 50, Ill.
Industrial Plastics, Ltd., London W.1, England
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Munson Mill Machinery Co., Utica 1, N. Y.
Novo Div., Industrial Enterprises, Inc., Chicago 28, Ill.
Patterson Foundry and Machine Co., The, E. Liverpool, Ohio
Pyramid Screen Corp., Brookline 46, Mass.
Rampe Mfg. Co., Cleveland 10, Ohio
Sprout, Waldron & Co., Inc., Muncy, Pa.
Sturtevant Mill Co., Boston 22, Mass.
Syntron Co., Homer City, Pa.
★Werner & Pfleiderer, Stuttgart, West Germany

SHEET FABRICATING MACHINES

★Air-O-Flow Industries, Inc., Div. of Durable Industries, Inc., New York 13, N. Y.
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany
Beck, Charles, Machine Corp., King of Prussia, Pa.
Blaw-Knox Co., Pittsburgh 22, Pa.
Borkland Mfg. Co., Marion, Ind.
★Comet Industries, Franklin Park, Ill.
Conapac Corp., New York 3, N. Y.
★D & R Plastic Welders, Inc., Hazardville, Conn.
Emhart Mfg. Co., Hudson, N. Y.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
★Famco Machine Co., Kenosha, Wis.
Industrial Plastics, Ltd., London W.1, England
Mereen Johnson Machine Co., Minneapolis 12, Minn.
★Omni Products Corp., New York 16, N. Y.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Taber Instrument Corp., N. Tonawanda, N. Y.

SHEET FORMING MACHINES

A. Pressure, Air
B. Pressure, Mechanical
C. Vacuum
D. Combination of Pressure and Vacuum

Abbott Plastic Machine Corp., Chicago 26, Ill. (A, B, C, D)
★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y. (C)
★Air-O-Flow Industries, Inc., Div. of Durable Industries, Inc., New York 13, N. Y. (A, B, C, D)
★Atlas Vac-Machine Corp., Rochester 21, N. Y. (A, C, D)
★Auto-Vac Co., Div. of National Cleveland Corp., Bridgeport 6, Conn. (A, B, C, D)
Blaw-Knox Co., Pittsburgh 22, Pa. (A, B, C, D)
Borkland Mfg. Co., Marion, Ind. (A, B, C, D)
Brenner, I. G., Co., Newark, Ohio (B)
★Brown Machine Co., Beaverton, Mich. (C, D)
★Comet Industries, Franklin Park, Ill. (A, B, C, D)
Conapac Corp., New York 3, N. Y. (C, D)
★Covema s.r.l., Milan, Italy (A, B, C, D)
★Daniels, T. H. & J., Ltd., Stroud, Gloucestershire, England (C, D)
Design Center, Inc., Long Island City 1, N. Y. (A, B, C, D)
Emhart Mfg. Co., Portland Div., Portland, Conn. (A, C, D)
Erdco Engineering Corp., Addison, Ill. (C, D)
Erinac Equipment Corp., New York 12, N. Y. (A, C, D)
Falge Engineering Corp., Bethesda 14, Md. (A, B, D)
Hydro-Chemie, Ltd., Zurich, Switzerland (A, C, D)
Industrial Plastics, Ltd., London W.1, England (C)
J M C Co., Newark 5, N. J. (A, B)
★Johnson Machinery Co., Newark 5, N. J. (C)
Kroll Equipment Co., Chicago 6, Ill. (C, D)
★Liberty Machine Co., Inc., Paterson 4, N. J. (B, D)
★Omni Products Corp., New York 16, N. Y. (C)
Packaging Industries Ltd., Inc., Montclair, N. J. (C)
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga. (C, D)
Plast-O-Craft Corp., Newark, N. J. (C, D)
Precision Products Co., Inc., Paterson, N. J. (C)
Product Packaging Engineering, Culver City, Calif. (C)
★Rainville Co., Inc., The, Garden City, N. Y. (A, C, D)
Thermomat Co. Inc., Trenton 8, N. J. (C)
★Triulzi, A. Off., s.a.s. Milan, Italy (C, D)
Zack Radiant Heet Co., Lodi, N. J. (C)

★ Indicates Advertiser

(For complete addresses, see Alphabetical Index, p. 1214)

SILK SCREENING EQUIPMENT

★Finish Engineering Co., Inc., Erie, Pa.
General Research & Supply Co., Grand Rapids 3, Mich.
Markem Machine Co., Keene, N. H.
Miskella Infra-Red Co., Inc., The, Cleveland 4, Ohio
Screen-O-Printer Mfg. Co., Adams, Mass.
Wallace, L. R., & Co., Pasadena 1, Calif.
Whitaker, Douglas C., Co., Glenside, Pa.

SLITTING MACHINES

Abbott Plastic Machine Corp., Chicago 26, Ill.
Al-Be Industries, South Gate, Calif.
★Appleton Machine Co., Doven Div., Appleton, Wis.
Beck, Charles, Machine Corp., King of Prussia, Pa.
★Black-Clawson Co., The, Dilts Div., Fulton, N. Y.
Blaw-Knox Co., Pittsburgh 22, Pa.
Brenner, I. G., Co., Newark, Ohio
★Buss Machine Works, Inc., Holland, Mich.
★Cameron Machine Co., Dover, N. J.
★Comet Industries, Franklin Park, Ill.
Conapac Corp., New York 3, N. Y.
★Cumberland Engineering Co., Inc., Providence 1, R. I.
★Dusenbery, John, Co., Verona, N. J.
Eastman Machine Co., Buffalo 3, N. Y.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
★Fecken-Kirfel Maschinenfabrik, Aachen, West Germany
G & S Label Corp., New York 1, N. Y.
★Gane Bros. & Lane, Inc., Chicago 7, Ill.
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
★Hobbs Mfg. Co., Worcester 5, Mass.
★Hofmann & Schwabe K. G., Krefeld, West Germany
Inta Roto Machine Co., Richmond 3, Va.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Liberty Machine Co., Inc., Paterson 4, N. J.
Maimin, H., Co., Inc., New York 18, N. Y.
Mereen Johnson Machine Co., Minneapolis 12, Minn.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Ruf Machine Co., Inc., New York 28, N. Y.
Shannon, Alexander J., Co., The, New York 38, N. Y.
Skil Corp., Chicago 30, Ill.
Stanford Engineering Co., Salem, Ill.
Swan Machine Co., New York 1, N. Y.
Turner Tanning Machinery Co., The, Peabody, Mass.
★Waldron, John, Corp., New Brunswick, N. J.

SLITTING AND MANGLING MACHINES

★Appleton Machine Co., Doven Div., Appleton, Wis.
★Cumberland Engineering Co., Inc., Providence 1, R. I.
★Fecken-Kirfel Maschinenfabrik, Aachen, West Germany
Monkley Corp., Worcester 8, Mass.

SLUSH MOLDING MACHINES

Blaw-Knox Co., Pittsburgh 22, Pa.
★Blue, E. B., Co., S. Norwalk, Conn.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.

SPOOLING MACHINES FOR EXTRUSIONS

Al-Be Industries, South Gate, Calif.
Emery, Vern, Co., Sun Valley, Calif.
Entwistle Mfg. Corp., Providence 7, R. I.
★Faeco Machine Co., Inc., Paterson, N. J.
Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany
★Foster & Allen, Inc., Chatham, N. J.
General Engineering Co., Radcliffe, Lancs., England
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
★Hobbs Mfg. Co., Worcester 5, Mass.
J M C Co., Newark 5, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Litzler, C. A., Co., Inc., Cleveland, Ohio
★Modern Plastic Machinery Corp. Lodi, N. J.
★Omni Products Corp., New York 16, N. Y.
★Progressive Machine Co., Inc., Paterson 4, N. J.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Ruf Machine Co., Inc., New York 28, N. Y.
Web Controls Corp., W. Englewood, N. J.

SPRAY PAINTERS, AUTOMATIC

★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
★Binks Mfg. Co., Chicago 12, Ill.
Clair Mfg. Co., Inc., Olean, N. Y.
★Conforming Matrix Corp., Toledo 2, Ohio
DeVilbiss Co., The, Toledo 1, Ohio
Electric Trading Co., New York 13, N. Y.
★Finish Engineering Co., Inc., Erie, Pa.
★Mercury Molding Machinery, Inc., Yonkers, N. Y.
★Sepanski & Associates, Grand Rapids 5, Mich.
Whitaker, Douglas C., Co., Glenside, Pa.

SPRAYUP EQUIPMENT FOR REINFORCED PLASTICS

A. Complete Systems
B. Resin Guns
C. Glass Breakers (Choppers)

★Aust & Schüttler u. Co., Düsseldorf, West Germany (B)
★Binks Mfg. Co., Chicago 12, Ill. (B)
Brenner, I. G., Co., Newark, Ohio (C)
DeVilbiss Co., The, Toledo 1, Ohio (B)
Fiberlay, Inc., Seattle 9, Wash. (A)
Gusmer, A., Inc., Woodbridge, N. J. (A, C)
Hupp Engineering Associates, Sarasota, Fla. (A, B, C)
Paasche Airbrush Co., Chicago 14, Ill. (B)
Peterson Spray Gun Co., San Mateo, Calif. (A, B, C)
Rand Development Corp., Cleveland 10, Ohio (A)
SealZit Co. of America, Riverside, Calif. (A)

SQUARING SHEARS

★Famco Machine Co., Kenosha, Wis.
★Hobbs Mfg. Co., Worcester 5, Mass.
Niagara Machine & Tool Works, Buffalo 11, N. Y.
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass.
Simonds Saw & Steel Co., Fitchburg, Mass.
Spadone Machine Co., Inc., S. Norwalk, Conn.
Wysong & Miles Co., Greensboro, N. C.

STATIC ELIMINATORS

Carbert Mfg. Co., Inc., Cambridge 39, Mass.
Herbert Products, Inc., Woodhaven 21, N. Y.
★Liberty Machine Co., Inc., Paterson 4, N. J.
Portland Co., The, Portland, Maine
Simco Co., The, Lansdale, Pa.
Statikil, Inc., Cleveland 13, Ohio
Sticht, Herman H., Co., Inc., New York 7, N. Y.
United States Radium Corp., Morristown, N. J.

TABLES, ELEVATING

★Adamson United Co., Akron 4, Ohio
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio
★Clifton Hydraulic Press Co., Clifton, N. J.
Economy Engineering Co., Chicago 24, Ill.
★Erie Engine & Mfg. Co., Erie, Pa.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
★French Oil Mill Machinery Co., The, Piqua, Ohio
Hamilton Tool Co., The, Hamilton, Ohio
Iddon Brothers Ltd., Leyland, Lancashire, England
Lewis-Shepard Products, Inc., Watertown 72, Mass.
Mercury Industries, Inc., Hillsdale, N. J.

TAKE-OFF EQUIPMENT

★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
★Adamson United Co., Akron 4, Ohio
Al-Be Industries, South Gate, Calif.
★Associated Equipment Corp., Bellevue, Wash.
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany
★Brown Machine Co., Beaverton, Mich.
Continental Machinery Co., Inc., New York 7, N. Y.
★Covema s.r.l., Milan, Italy
★Davis-Standard Div., Franklin Research Corp., Mystic, Conn.
★Dusenbery, John, Co., Verona, N. J.
★Egan, Frank W., & Co., Somerville, N. J.
Entwistle Mfg. Corp., Providence 7, R. I.
★Faeco Machine Co., Inc., Paterson, N. J.
★Foster & Allen, Inc., Chatham, N. J.
General Engineering Co., Radcliffe, Lancs., England
★Goulding Mfg. Co., Saginaw, Mich.

★ Indicates Advertiser

★H&T Machine Works, Houston, Texas
Heinrich Equipment Corp., New York 11, N. Y., U. S. Rep. for Reifenhauser Plastics Machinery Corp.
★Hobbs Mfg. Co., Worcester 5, Mass.
Iddon Brothers, Ltd., Leyland, Lancashire, England
Island Equipment Corp., Hialeah, Fla.
J M C Co., Newark 5, N. J.
★Johnson Mfg. Co., Inc., Chippewa Falls, Wis.
★Kato Seishakusho Co., Ltd., Tokyo, Japan
★Killion Tool & Mfg. Co., Verona, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
Lavorazione Materie Plastiche, s.a.s., Torino, Italy
★Liberty Machine Co., Inc., Paterson 4, N. J.
★Litzler, C. A., Co., Inc., Cleveland 9, Ohio
★Modern Plastic Machinery Corp., Lodi, N. J.
Mount Hope Machinery Co., Taunton, Mass.
★Negri Bossi & Co., Milan, Italy
★Omni Products Corp., New York 16, N. Y.
Pasquetti, Carlo, & C.S.A., Fabbrica Prodotti Termoplastici, Varese-Masnago, Italy
★Peco Machinery Sales (Westminster), Ltd., London, S.W.1, England
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastimaster Co., Houston 16, Texas
★Prodex Corp., Fords, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
★Reifenhauser Plastics Machinery Co., Troisdorf, Bez-Koln, West Germany
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.
★Robbins Plastic Machinery Corp., Elkhart, Ind.
★Servospeed Div., Electro-Devices, Inc., Paterson, N. J.
Shannon, Alexander J., Co., The, New York 38, N. Y.
Sherman Rubber Co., Div. of Bowinik Bros. of Mass., Inc., Worcester, Mass.
★Sterling Extruder Corp., Linden, N. J.
★Waldron, John, Corp., New Brunswick, N. J.
Web Controls Corp., W. Englewood, N. J.

TESTING APPARATUS

(See Instruments, p. 1132)

TRANSFER MOLDING PRESSES

★Adamson United Co., Akron 4, Ohio
Atlas Hydraulics Div., Delaware Valley Mfg. Co., Inc., Philadelphia 34, Pa.
Automold Co., Subsidiary of Wagner Bros., Inc., W. Los Angeles 64, Calif.
★B. I. P. Engineering, Ltd., Sutton Coldfield, Warwickshire, England
Baker Bros., Toledo 10, Ohio
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio
Bradley & Turton, Ltd., Kidderminster, England
Clearing Div. of U. S. Industries, Inc., Chicago 38, Ill.
★Clifton Hydraulic Press Co., Clifton, N. J.
★Covema s.r.l., Milan, Italy
Custom Machine & Design, Inc., Akron 9, Ohio
★Dake Corp., Grand Haven, Mich.
★Daniels, T. H. & J., Ltd., Stroud, Gloucestershire, England
★Dunning & Boschert Press Co., Inc., The, Syracuse, N. Y.
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio
★Erie Engine & Mfg. Co., Erie, Pa.
Erinac Equipment Corp., New York 12, N. Y.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
★French Oil Mill Machinery Co., The, Piqua, Ohio
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill.
★Hull-Standard Corp., Hatboro, Pa.
★Hydraulic Press Mfg. Co., The, A Div. of Koehring Co., Mount Gilead, Ohio
★Improved Machinery, Inc., Nashua, N. H.
★Johnson Machinery Co., Newark, N. J.
★Karlton Machinery Corp., Chicago, Ill.
★Lawton, C. A., Co., The, De Pere, Wis.
Lempco Industrial, Inc., Bedford, Ohio
★Logan Hydraulics, Inc., Chicago, Ill.
Machinery Factory & Foundry, Ltd., Netstal, Switzerland
★Omni Products Corp., New York, N. Y.
Pasadena Hydraulics, Inc., El Monte, Calif.
Rodgers Hydraulic, Inc., Minneapolis 26, Minn.
★Stokes, F. J., Corp., Philadelphia 20, Pa.
★Symons, Ralph B., Associates, Inc., Tiverton, R. I.
★Triulzi, A. Off., s.a.s., Milan, Italy
Verson Allsteel Press Co., Chicago 19, Ill.
Wabash Metal Products Co., Inc., Wabash, Ind.
★Watson-Stillman Press Div., Farrel-Birmingham Co., Inc., Rochester 10, N. Y.
★Williams-White & Co., Moline, Ill.
★Wood, R. D., Co., Philadelphia 5, Pa.

TRAPS, STEAM

Armstrong Machine Works, Three Rivers, Mich.
Perfecting Service Co., Charlotte 6, N. C.
Powers Regulator Co., The, Skokie 34, Ill.
★Sarco Co., Inc., New York 22, N. Y.
Yarnall-Waring Co., Philadelphia 18, Pa.

TRIMMING PRESSES

★Adamson United Co., Akron 4, Ohio
★Atlas Vac-Machine Corp., Rochester 21, N. Y.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Bliss, E. W., Co., Canton 10, Ohio
★Clifton Hydraulic Press Co., Clifton, N. J.
Conapac Corp., New York 3, N. Y.
★Dake Corp., Grand Haven, Mich.
★Elmes Engineering Div., American Steel Foundries, Cincinnati 29, Ohio
★Erie Foundry Co., Erie, Pa.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
★Goulding Mfg. Co., Saginaw, Mich.
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill.
★Hydraulic Press Mfg. Co., The, A Div. of Koehring Co., Mount Gilead, Ohio
Hydro-Chemie, Ltd., Zurich, Switzerland
Lempco Industrial, Inc., Bedford, Ohio
★M & N Hydraulic Press Co., Inc., Clifton, N. J.
Niagara Machine & Tool Works, Buffalo 11, N. Y.
Oliver Corp., The, A. B. Farquhar Div., York, Pa.
Studebaker Hydraulic Products Co., Melrose Park, Ill.
★Tronomatic Machine Mfg. Corp., New York 35, N. Y.
Verson Allsteel Press Co., Chicago, Ill.
★Williams-White & Co., Moline, Ill.

TUBE ROLLING MACHINES

★Berstorff, Herman, Maschinenbau GmbH, Hannover, West Germany
Borkland Mfg. Co., Marion, Ind.
★Faeco Machine Co., Inc., Paterson, N. J.
General Engineering Co., Radcliffe, Lancs., England
★Liberty Machine Co., Inc., Paterson 4, N. J.
Wilson, Thomas C., Inc., Long Island City 1, N. Y.

TUMBLING MACHINES

Abbe Engineering Co., New York, 17, N. Y.
★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
★Ball & Jewell, Inc., Brooklyn 2, N. Y.
Crown Machinery, Inc., Los Angeles 11, Calif.
★Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio
Ferry Machine Co., Kent, Ohio
★Injection Molders Supply Co., Cleveland 20, Ohio
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
★Omni Products Corp., New York, N. Y.
Patterson-Kelley Co., Inc., The, E. Stroudsburg, Pa.
Rainco Mfg., Inc., Franklin, Pa.
Ransohoff Co., Hamilton, Ohio
Siebert, R. R., Co., The, Rochester 4, N. Y.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.
★Tumb-L-Matic, Inc., Stamford, Conn.
Wheelabrator Corp., Mishawaka, Ind.

ULTRASONIC CLEANING EQUIPMENT

Branson Ultrasonic Corp., Stamford, Conn.
Cooper, D. C., Co., Chicago 5, Ill.
Hermes Sonic, New York 11, N. Y.
Randall Mfg. Co., Inc., New York 59, N. Y.
Ransohoff Co., Hamilton, Ohio

USED AND REBUILT MACHINES

Abbott Machinery Co., Union City, N. J.
★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
Albert, P. E., & Son, Trenton 5, N. J.
★Bolling, Stewart, & Co., Inc., Cleveland 27, Ohio
Crown Machinery, Inc., Los Angeles 11, Calif.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
First Machinery Corp., Brooklyn 15, N. Y.
★Guild Electronics, Inc., Dynatherm Div., New York 13, N. Y.
★Hochman Plastics Machinery Corp., Newark 2, N. J.
★Johnson Machinery Co., Newark 5, N. J.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.

★ Indicates Advertiser

Plastic Machinery Exchange, Boonton, N. J.
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.
Ross, Charles, & Son Co., Brooklyn 5, N. Y.
Sherman Rubber Co., Div. of Botwinik Bros. of Mass., Inc., Worcester, Mass.
★Thermatron Co., The, Div. of Willcox & Gibbs Sewing Machine Co., New York 18, N. Y.
Verduin, John, Machine Corp., Paterson 4, N. J.
Web Controls Corp., W. Englewood, N. J.

VACUUM FORMING MACHINES

(See Sheet Forming Machines)

VACUUM METALLIZING EQUIPMENT

★Consolidated Electrodynamics Corp., Rochester Div., Rochester 3, N. Y.
Dorrie Process Co., Inc., Brooklyn 2, N. Y.
Edwards High Vacuum, Inc., Niagara Falls, N. Y.
General Engineering Co., Radcliffe, Lancs., England
High Vacuum Equipment Corp., Hingham, Mass.
★Hull Corp., Hatboro, Pa.
★NRC Equipment Corp., Newton 61, Mass.
★Stokes, F. J., Corp., Philadelphia 20, Pa.

VACUUM PLATING HOLDING RACKS

★Consolidated Electrodynamics Corp., Rochester Div., Rochester 3, N. Y.
★Finish Engineering Co., Inc., Erie, Pa.
Seal Cast Co., Inc., Philadelphia 25, Pa.

VIBRATORS

Exact Weight Scale Co., Columbus 15, Ohio
Gump, B. F., Co., Chicago 50, Ill.

★ Indicates Advertiser

Industrial Plastics, Ltd., London W.1, England
Miskella Infra-Red Co., Inc., The, Cleveland 4, Ohio
Plastics Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Syntron Co., Homer City, Pa.

WEIGH-FEEDERS

Exact Weight Scale Co., Columbus 15, Ohio
Glengarry Processes, Inc., Bay Shore, N. Y.
Gump, B. F., Co., Chicago 50, Ill.
Industrial Plastics, Ltd., London W.1, England
Mercury Heat Sealing Equipment Co., Philadelphia 33, Pa.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Proctor & Schwartz, Inc., Philadelphia 20, Pa.
★Rainville Co., Inc., The, Garden City, N. Y.
Richardson Scale Co., Clifton, N. J.
Syntron Co., Homer City, Pa.
Toledo Scale, Div. of Toledo Scale Corp., Toledo 12, Ohio
★Wallace & Tiernan, Inc., Belleville 9, N. J.
Weighing & Control Components, Inc., Hatboro, Pa.

WELDING EQUIPMENT FOR PLASTICS

American Agile Corp., Bedford, Ohio
Borkland Mfg. Co., Marion, Ind.
★Cosmos Electronic Machine Corp., New York 12, N. Y.
★D & R Plastic Welders, Inc., Hazardville, Conn.
Hydro-Chemie, Ltd., Zurich, Switzerland
Kabar Mfg. Corp., N. Y. 62, N. Y.
★Possis Machine Corp., Minneapolis 3, Minn.
Quelcor, Inc., Chester, Pa.
Radio Frequency Co., Inc., Medfield, Mass.
Radio Heaters, Ltd., Wokingham, Berks, England
★Rainville Co., Inc., The, Garden City, N. Y.

Reeve Electronics, Inc., Chicago 6, Ill.
★Sealomatic Electronics Corp., Brooklyn 11, N. Y.
★Seelye Craftsmen, Minneapolis, Minn.
Societe de L'Electronique Fse., Asnieres, Seine, France
★Thermatron Co., The, Div. of Willcox & Gibbs Sewing Machine Co., New York 18, N. Y.

WIRE COATING MACHINES

Al-Be Industries, South Gate, Calif.
★Battenfeld Maschinenfabriken GmbH, Meinerzhagen/Westf., West Germany
★Covema s.r.l., Milan, Italy
★Davis-Standard Div., Franklin Research Corp., Mystic, Conn.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
General Engineering Co., Radcliffe, Lancs., England
★Hartig Extruders Div., Midland-Ross Corp., Mountainside, N. J.
Iddon Brothers Ltd., Leyland, Lancashire, England
★Industrial Ovens, Inc., Cleveland 11, Ohio
Industrial Plastics, Ltd., London W.1, England
J M C Co., Newark 5, N. J.
★Johnson Machinery Co., Newark, N. J.
★Litzler, C. A., Co., Inc., Cleveland, Ohio
Michigan Oven Co., Deroit 1, Mich.
★Modern Plastic Machinery Corp., Lodi, N. J.
★Negri Bossi & Co., Milan, Italy
★Omni Products Corp., New York 16, N. Y.
★Prodex Corp., Fords, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
★Royle, John, & Son, Paterson 3, N. J.
★Shaw, Francis, & Co., Ltd., Manchester 11, England
★Sterling Extruder Corp., Linden, N. J.
Whitaker, Douglas C., Co., Glenside, Pa.

WIRE WRAPPING MACHINES

Pierce Wrapping Machine Co., La Grange, Ill.

Instruments

For list of distributors, see p. 1162

CONTROLLING INSTRUMENTS

A. Temperatures (Dial and Glass Thermometers, Potentiometers, Resistance Thermometers, Thermocouples, etc.)
B. Surface Pyrometers
C. Pressure, to 200 p.s.i.
D. Pressure, 200 p.s.i. and up
E. Flow of Fluids
F. Flow of Solid Particles
G. Time and Machine Cycling
H. Mold Closing
I. Weight
J. Extrusion Take-Off
K. Drive Speed
L. Thickness (or Density of Webs and Extrudates)

★Barber-Colman Co., Wheelco Instruments Div., Rockford, Ill. (A, B)
Boulin Instrument Corp., Pelham, N. Y. (K)
★Brabender, C. W., Instruments, Inc., S. Hackensack, N. J. (E)
★Cambridge Instrument Co., Inc., New York 17, N. Y. (B)
Curtiss-Wright Corp., Electronics Div., Industrial Controls Dept., Carlstadt, N. J. (I, L)
Eagle Signal Corp., Moline, Ill. (G)
Eclipse Fuel Engineering Co., Rockford, Ill. (E)
Electric Auto-Lite Co., The, Toledo 1, Ohio (A)
Electronic Processes Corp. of Calif., San Francisco 7, Calif. (A, G)
Exact Weight Scale Co., Columbus 15, Ohio (I)
Fenwal, Inc., Ashland, Mass. (A, C)
Fischer & Porter Co., Hatboro, Pa. (A, C, D, E)
★Foster & Allen, Inc., Chatham, N. J. (G, J)
Foxboro Co., The, Foxboro, Mass. (A, B, C, D, E, F, G, H, I, J, K, L)
GPE Controls Inc., Chicago 11, Ill. (C, D, E, G, K, L)
Gabriel Mfg. Co., Haverstraw, N. Y. (D)
★General Electric Co., Apparatus Sales Div., Schenectady 5, N. Y. (A, B, C, D, E, G, K)
★Glenn Electric Heater Corp., Newark 8, N. J. (A, B, G)
Haynes & Haynes, Ltd., London, S.W. 3, England (J, L)
Helicoid Gage Div., American Chain & Cable, Bridgeport, Conn. (C, D)
Illinois Testing Laboratories, Inc., Chicago 10, Ill. (B)
★Industrial Mfg. Corp., Indianapolis 4, Ind. (A)
Industrial Nucleonics Corp., Columbus 26, Ohio (E, F, I, L)
Jones Motrola Corp., Stamford, Conn. (A, K)
Leeds & Northrup Co., Philadelphia 44, Pa. (A, B, C, D)
Leslie Co., Lyndhurst, N. J. (A, C, D)
★Mayer Refrigerating Engineers, Lincoln Park, N. J. (A)
Minneapolis-Honeywell Regulator Co., Minneapolis 8, Minn. (A, C, D, E, G, K, L)
Partlow Corp., The, New Hartford, N. Y. (A, G)
★Peco Machinery Sales (Westminster), Ltd., London S.W.1, England (J)
Photobell Co., Inc., New York 7, N. Y. (F, I, L)
Photomation, Inc., Bergenfield, N. J. (E, F, I, J, L)
Plastics by Chapman, Richmond, Calif. (C, E, G)
Powers Regulator Co., The, Skokie 34, Ill. (A, C, D, E)
Pyrometer Instrument Co., Inc., Bergenfield, N. J. (A, B)
Pyrometer Service Co., Inc., N. Arlington, N. J. (A)
★Rainville Co., Inc., The, Garden City, N. Y. (B)
★Reliance Electric & Engineering Co., Cleveland 17, Ohio (A, G, K)
Richardson Scale Co., Clifton, N. J. (I)
★Sarco Co., Inc., New York 22, N. Y. (A)
★Sinclair-Collins Valve Co., The, Div. of International Basic Economy Corp., Akron 11, Ohio (E, H)
★Sterling, Inc., Milwaukee 18, Wis. (A, E, J)
Taylor-Emmett Controls, Inc., Akron 19, Ohio (G)
★Taylor Instrument Companies, Rochester 1, N. Y. (A, B, C, D, E, F, G, H, I)
Technique Associates, Inc., Indianapolis 2, Ind. (B)
★Thermo Electric Co., Inc., Saddle Brook, N. J. (A, B)
Thwing-Albert Instrument Co., Philadelphia 44, Pa. (A, B)
Toledo Scale, Div. of Toledo Scale Corp., Toledo 12, Ohio (I)
Tracerlab, Inc., Waltham 54, Mass. (E, F, I, L)
United Electric Controls Co., Watertown 72, Mass. (A, C, D)
Wabash Metal Products Co., Inc., Wabash, Ind. (B)
Wallace & Tiernan, Inc., Belleville 9, N. J. (E, G)
Weighing & Control Components, Inc., Hatboro, Pa. (I)
★West Instrument Corp., Chicago 41, Ill. (A, B)
Weston Instruments, Newark 12, N. J. (A, B, C, D, F, I, J, K, L)
Wilson, G. C., & Co., Huntington 2, Va. (G)

MEASURING INSTRUMENTS

A. Temperatures (Dial and Glass Thermometers, Potentiometers, Resistance Thermometers, Thermocouples, etc.)
B. Surface Pyrometers
C. Pressure, to 200 p.s.i.
D. Pressure, 200 p.s.i. and up
E. Flow of Fluids
F. Flow of Solid Particles
G. Time and Machine Cycling
H. Mold Closing
I. Weight
J. Extrusion Take-Off
K. Drive Speed
L. Thickness (or Density of Webs and Extrudates)

American Instrument Co., Inc., Silver Spring, Md. (A, L)
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa. (I, K)
★Barber-Colman Co., Wheelco Instruments Div., Rockford, Ill. (A, B)
Boulin Instrument Corp., Pelham, N. Y. (K)
★Brabender, C. W., Instruments, Inc., S. Hackensack, N. J. (E)
Branson Instruments, Inc., Stamford, Conn. (L)
★Cambridge Instrument Co., Inc., New York 17, N. Y. (B)
Curtiss-Wright Corp., Electronics Div., Industrial Controls Dept., Carlstadt, N. J. (I, L)
Dice, J. W., Co., Englewood, N. J. (L)
Dillon, W. C., & Co., Inc., Van Nuys, Calif. (I)
Eclipse Fuel Engineering Co., Rockford, Ill. (E)
Electric Auto-Lite Co., The, Toledo 1, Ohio (A)
Electronic Processes Corp., of Calif., San Francisco 7, Calif. (A)
Exact Weight Scale Co., Columbus 15, Ohio (E, F, I)
Fischer & Porter Co., Hatboro, Pa. (A, C, D, F)
Fisher Scientific Co., Pittsburgh 19, Pa. (A, I)
★Foster & Allen, Inc., Chatham, N. J. (G, J)
Foxboro Co., The, Foxboro, Mass. (A, B, C, D, E, F, G, H, I, J, K, L)
Haynes & Haynes Ltd. London, S.W.3, England (L)
Illinois Testing Laboratories, Inc., Chicago 10, Ill. (B)
Industrial Development Laboratories, Inc., Edgewater, N. J. (A)
Industrial Nucleonics Corp., Columbus 6, Ohio (E, G, I, L)
Jones Motrola Corp., Stamford, Conn. (A, K)
Leeds & Northrup Co., Philadelphia 44, Pa. (A, B, C, D)
Minneapolis-Honeywell Regulator Co., Minneapolis 8, Minn. (A, C, D, E, G, K, L)
Partlow Corp., New Hartford, N. Y. (A)
Photobell Co., Inc., New York 7, N. Y. (F, I, L)
Powers Regulator Co., The, Skokie 34, Ill. (A)
Pratt & Whitney Co., Inc., W. Hartford 1, Conn. (F, G, H, J, L)
Pyrometer Instrument Co., Inc., Bergenfield, N. J. (A, B)
Pyrometer Service Co., Inc., N. Arlington, N. J. (A)
★Rainville Co., Inc., The, Garden City, N. Y. (B)
★Reliance Electric & Engineering Co., Cleveland 17, Ohio (K)

★ Indicates Advertiser

Sticht, Herman H., Co., Inc., New York 7, N. Y. (K)
Taber Instrument Corp., N. Tonawanda, N. Y. (C, D)
★Taylor Instrument Companies, Rochester 1, N. Y. (A, B, C, D, E, F, G, H, I)
Technique Associates, Inc., Indianapolis 2, Ind. (B)
★Testing Machines, Inc., Mineola, N. Y. (A, B, C, D, L)
Toledo Scale, Div. of Toledo Scale Corp., Toledo 12, Ohio (I)
Tracerlab, Inc., Waltham 54, Mass. (E, F, I, L)
United Electric Controls Co., Watertown 72, Mass. (A, C, D)
United Sensor & Control Corp., Glastonbury, Conn. (A, C, D, E)
Wabash Metal Products Co., Inc., Wabash, Ind. (B)
Wallace & Tiernan, Inc., Belleville 9, N. J. (C, D, F)
★West Instrument Corp., Chicago 41, Ill. (A, B)
Weston Instruments, Newark, N. J. (A, B, C, D, F, I, J, K, L)

TESTING INSTRUMENTS FOR:

A. Color Matching
B. Electrical Properties
C. Electrical Quantities
D. Mechanical Properties
E. Moisture, Volatiles
F. Permeability Properties
G. Thermal Properties
H. Viscosity, Plasticity
I. Weathering
J. Miscellaneous Testing

American Instrument Co., Inc., Silver Spring, Md. (D, I, J)
★Atlas Electric Devices Co., Chicago 13, Ill. (I, J)
Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa. (D)
★Barber-Colman Co., Small Motors Div., Rockford, Ill. (D)
Beckman Instruments, Inc., Scientific & Process Instruments Div., Fullerton, Calif. (A)
Boulin Instrument Corp., Pelham, N. Y. (D)
★Brabender, C. W., Instruments, Inc., S. Hackensack, N. J. (D, E, G, H, J)
Branson Instruments, Inc., Stamford, Conn. (J)
Brookfield Engineering Laboratories, Inc., Stoughton, Mass. (H, J)
★Cady, E. J., & Co., River Forest, Ill. (J)
★Cambridge Instrument Co., Inc., New York 17, N. Y. (F)
Central Scientific Co., Chicago 13, Ill. (J)
Conapac Corp., New York 3, N. Y. (D)
Crown Engineering & Sales Co., Harrison, N. J. (A)
Curtiss-Wright Corp., Electronics Div., Industrial Controls Dept., Calstadt, N. J. (D, E)
Custom Scientific Instruments, Inc., Kearny, N. J. (B, D, G, J)
Delsen Corp., Glendale 4, Calif. (B, C, G)
Devco Engineering, Inc., Caldwell, N. J. (J)
Dice, J. W., Co., Englewood, N. J. (J)
Dietert, Harry W., Detroit 4, Mich. (E)
Dillon, W. C., & Co., Inc., Van Nuys, Calif. (D)
Entwistle Mfg. Corp., Providence 7, R. I. (B)
Fenwal, Inc., Ashland, Mass. (G)
Ferry Machine Co., Kent, Ohio (D, J)
Fisher Scientific Co., Pittsburgh 19, Pa. (J)
★Furane Plastics, Inc., Los Angeles 39, Calif. (B, C)
Gaertner Scientific Corp., Chicago 14, Ill. (H)
Gardner Laboratory, Inc., Bethesda 14, Md. (H)
Gaynes Engineering Co., Chicago 12, Ill. (J)
★General Electric Co., Apparatus Sales Div., Schenectady 5, N. Y. (B, C, D, G)
Hallikainen Instruments, Berkeley 10, Calif. (H)
Hydro-Chemie, Ltd., Zurich, Switzerland (D)
Industrial Development Laboratories, Inc., Edgewater, N. J. (C)
Industrial Devices Inc., Edgewater, N. J. (C)
Instron Engineering Corp., Canton, Mass. (D)
Macbeth Corp., Newburgh, N. Y. (A)
Manufacturers Engineering & Equipment Corp., Hatboro, Pa. (J)
Minneapolis-Honeywell Regulator Co., Minneapolis 8, Minn. (B, C, D, G, I, J)
Moisture Register Co., Alhambra, Calif. (E)
Moore-Milford Corp., Skokie, Ill. (E)
Photobell Co., Inc., New York 7, N. Y. (B, C, J)
Photomation, Inc., Bergenfield, N. J. (J)
Plas-Tech Equipment Corp., Waltham 54, Mass. (D)
Product Packaging Engineering, Culver City, Calif. (G)
Pyrometer Service Co., Inc., N. Arlington, N. J. (G)
Resistoflex Corp., Roseland, N. J. (G)
Schlumberger Corp., Ridgefield, Conn. (E)
★Scott Testers, Inc., Providence 1, R. I. (D, J)
Sieburg Industries, Inc., Danbury, Conn. (D, J)
Soiltest, Inc., Chicago 39, Ill. (D, J)
Sticht, Herman H., Co., Inc., New York 7, N. Y. (B, C)
Taber Instrument Corp., N. Tonawanda, New York (J)
★Testing Machines, Inc., Mineola, N. Y. (D, G, I, J)
United Electric Controls Co., Watertown 72, Mass. (J)
United States Testing Co., Inc., Hoboken, N. J. (B, D, G, J)
Wallace & Tiernan, Inc., Belleville 9, N. J. (J)
Weston Instruments, Div. of Daystrom, Inc., Newark 12, N. J. (B, C, G, J)

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Machine Tools

For list of distributors, see p. 1162

BEVELING MACHINES

★Ackerman Gould Co., Oceanside, N. Y.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
★Mico Instrument Co., Cambridge 38, Mass.
★New Hermes Engraving Machine Corp., New York 11, N. Y.
Sommer & Maca Glass Machinery Co., Chicago 50, Ill.
★Standard Tool Co., Leominster, Mass.

BORING MACHINES

Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
Ketchpel Engineering Co., W. Englewood, N. J.
Motch & Merryweather Machinery Co., Cleveland 17, Ohio
★National Automatic Tool Co., Richmond, Ind.
Snyder Corp., Detroit 7, Mich.
Union Tool Corp., The, Warsaw, Ind.

BROACHING MACHINES

Cincinnati Milling Machine Co., The, Milling Machine Div., Cincinnati 9, Ohio
Greenerd Arbor Press Co., Nashua, N. H.

BUFFING MACHINES

Divine Bros., Co., Utica 1, N. Y.
Foredom Electric Co., Inc., Bethel, Conn.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Maplewood Companies, Livingston, N. J.
Nash, J. M., Co. Inc., Milwaukee 45, Wis.
Sommer & Maca Glass Machinery Co., Chicago 50, Ill.
Wyzenbeck & Staff, Inc., Chicago 12, Ill.

CUTTING TOOLS
(Cutters, Millers, Routers, etc.)

★Birbach, L. E., Associates, Inc., Draco Div., Boston (Malden) 48, Mass.
Crucible Steel Co. of America, Pittsburgh 30, Pa.
★DoAll Co., The, Des Plaines, Ill.
Elgin National Watch Co., Abrasives Div., Elgin, Ill.
★Fecken-Kirfel Maschinenfabrik, Aachen, West Germany
Firth Sterling, Inc., Pittsburgh 30, Pa.
Foredom Electric Co., Inc., Bethel, Conn.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Melin Tool Co., Inc., Cleveland 11, Ohio
Meyers, W. F., Co., Inc., Bedford, Ind.
Pratt & Whitney Co., Inc., W. Hartford 1, Conn.
Radial Cutter Mfg. Corp., Elizabeth 4, N. J.
Sieburg Industries, Inc., Danbury, Conn.

DIE SINKING MACHINES

Bliss, E. W., Co., Canton 10, Ohio
Cincinnati Milling Machine Co., The Milling Machine Div., Cincinnati 9, Ohio
Defiance Machine & Tool Co., St. Louis 10, Mo.
Erinac Equipment Corp., New York 12, N. Y.
★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio
★Gorton, George, Machine Co., Racine, Wis.
Pratt & Whitney Co., Inc., W. Hartford 1, Conn.
Turchan Follower Machine Co., Inkster, Mich.

DRILLING MACHINES

A. Drill Presses, Single Spindle
B. Drill Presses, Multiple Spindle
C. Jig Borers
D. Portable

Air Speed Tool Co., Los Angeles 47, Calif. (D)
American Edelstaal, Inc., New York 13, N. Y. (A)
Aro Equipment Co., Bryan, Ohio (D)
Barker-Davis Machine Co., Inc., Leominster, Mass. (A, B)
Black & Decker Mfg. Co., The, Industrial Div., Towson, Md. (D)
Boice-Crane Co., Toledo 6, Ohio (A, B)
Buckeye Tools Corp., Dayton, Ohio (D)
Buttondex Corp., New York 16, N. Y. (A, B)
Chicago Pneumatic Tool Co., New York 17, N. Y. (D)
★Electro-Mechano Co., The, Milwaukee 2, Wis. (A, B)
Erinac Equipment Corp., New York 12, N. Y. (C)
★Famco Machine Co., Kenosha, Wis. (A, B)
Gardner-Denver Co., Quincy, Ill. (D)
Hamilton Tool Co., The, Hamilton, Ohio (A, B)
Ingersoll-Rand Co., New York 4, N. Y. (D)
Ketchpel Engineering Co., W. Englewood, N. J. (A)
★Mico Instrument Co., Cambridge 38, Mass. (A)
Motch & Merryweather Machinery Co., Cleveland 17, Ohio (A, B)
★National Automatic Tool Co., Richmond, Ind. (B)
Porter-Cable Machine Co., Syracuse 4, N. Y. (C, D)
Pratt & Whitney Co., Inc., W. Hartford 1, Conn. (C)
Remington Arms Co., Inc., Bridgeport 2, Conn. (P)
Skil Corp., Chicago 30, Ill. (D)
Snyder Corp., Detroit 7, Mich. (A, B)
Sommer & Maca Glass Machinery Co., Chicago 50, Ill. (A, B)
Thor Power Tool Co., Aurora, Ill. (D)

DUPLICATING MACHINES

A. Two-Dimensional
B. Three-Dimensional

Cincinnati Milling Machine Co., The, Milling Machine Div., Cincinnati 9, Ohio (A, B)
Erinac Equipment Corp., New York 12, N. Y. (A, B)
★Famco Machine Co., Kenosha, Wis. (A, B)
★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A, B)
★Gorton, George, Machine Co., Racine, Wis. (A, B)
Pratt & Whitney Co., Inc., W. Hartford 1, Conn. (A, B)
Technicraft Co., Boston 34, Mass. (B)
Turchan Follower Machine Co., Inkster, Mich. (A, B)

ENGRAVING MACHINES

Defiance Machine & Tool Co., St. Louis 10, Mo.
Foredom Electric Co., Inc., Bethel, Conn.
★Gorton, George, Machine Co., Racine, Wis.
Green Instrument Co., Inc., Cambridge 39, Mass.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Mico Instrument Co., Cambridge, Mass.
★New Hermes Engraving Machine Corp., New York 11, N. Y.
Pierce Wrapping Machine Co., La Grange Pk. (Chicago Suburb), Ill.
★Preis, H. P., Engraving Machine Co., Hillside 5, N. J.
Technicraft Co., Boston 34, Mass.

GRINDING MACHINES

A. Bench Grinders
B. Centerless Grinders
C. Internal Grinders
D. Portable Grinders
E. Surface Grinders
F. Universal and Tool Grinders

American Edelstaal, Inc., New York 13, N. Y. (E)
Black & Decker Mfg. Co., The, Industrial Div., Towson, Md. (D)
Chicago Wood & Plastic Products, Chicago 41, Ill. (B)
Cincinnati Milling Machine Co., The, Grinding Machine Div., Cincinnati 9, Ohio (B)
Cincinnati Milling Machine Co., The, Milling Machine Div., Cincinnati 9, Ohio (F)
★DoAll Co., The, Des Plaines, Ill. (E)
★Engineering Laboratories, Inc., Pompton Lakes, N. J. (B)
Erinac Equipment Corp., New York 12, N. Y. (E)

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- ★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A, F)
- Foredom Electric Co., Inc., Bethel, Conn. (C, D, E, F)
- ★Gorton, George, Machine Co., Racine, Wis. (F)
- ★Mico Instrument Co., Cambridge 38, Mass. (F)
- ★New Hermes Engraving Machine Corp., New York 11, N. Y. (A, D)
- Norton Co., Worcester 6, Mass. (B, E, F)
- Porter-Cable Machine Co., Syracuse 4, N. Y. (A, D)
- Pratt & Whitney Co., Inc., W. Hartford 1, Conn. (C, E, F)
- Skil Corp., Chicago 30, Ill. (D, E, F)
- Stow Mfg. Co., Binghamton, N. Y. (D)
- Wilson, Thomas C., Inc., Long Island City 1, N. Y. (D)
- Wyzenbeek & Staff, Inc., Chicago 12, Ill. (D)

LATHES

(Turning, Boring, etc.)

- American Edelstaal, Inc., New York 13, N. Y.
- Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa.
- Bliss, E. W., Co., Canton 10, Ohio
- ★Farrel-Birmingham Co., Inc., Ansonia, Conn.
- Lodge & Shipley Co., The, Cincinnati 25, Ohio
- Taber Instrument Corp., N. Tonawanda, New York

MILLING MACHINES

A. Plain Milling
B. Rotary Head Milling
C. Universal Milling
D. Vertical Milling

- American Edelstaal, Inc., New York 13, N. Y. (D)
- Cincinnati Milling Machine Co., The, Milling Machine Div., Cincinnati 9, Ohio (A, C, D)
- ★Famco Machine Co., Kenosha, Wis. (C, D)
- ★Farrel-Birmingham Co., Inc., Ansonia, Conn. (A, B, D)
- ★Gorton, George, Machine Co., Racine, Wis. (A, C, D)
- Turchan Follower Machine Co., Inkster, Mich. (D)

PANTOGRAPHS

- Erinac Equipment Corp., New York 12, N. Y.
- ★Gorton, George, Machine Co., Racine, Wis.
- Green Instrument Co., Inc., Cambridge 39, Mass.
- ★Mico Instrument Co., Cambridge 38, Mass.
- ★New Hermes Engraving Machine Corp., New York 11, N. Y.
- Pierce Wrapping Machine Co., La Grange Pk. (Chicago Suburb), Ill.
- ★Preis, H. P., Engraving Machine Co., Hillside 5, N. J.
- Technicraft Co., Boston 34, Mass.

PLANING AND SHAPING MACHINES

- Baldwin-Lima-Hamilton Corp., Philadelphia 7, Pa.
- Boice-Crane Co., Toledo 6, Ohio
- ★Farrel-Birmingham Co., Inc., Ansonia, Conn.
- Porter-Cable Machine Co., Syracuse 4, N. Y.

PROFILING MACHINES

- Chicago Wood & Plastic Products, Chicago 41, Ill.
- Erinac Equipment Corp., New York 12, N. Y.
- ★Farrel-Birmingham Co., Inc., Ansonia, Conn.
- Foredom Electric Co., Inc., Bethel, Conn.
- ★Gorton, George, Machine Co., Racine, Wis.
- ★New Hermes Engraving Machine Corp., New York 11, N. Y.
- Pratt & Whitney Co., Inc., W. Hartford 1, Conn.
- Sieburg Industries, Inc., Danbury, Conn.
- Taber Instrument Corp., N. Tonawanda, N. Y.
- Turchan Follower Machine Co., Inkster, Mich.

ROUTING MACHINES

- Black & Decker Mfg. Co., The, Industrial Div., Towson, Md.
- Foredom Electric Co., Inc., Bethel, Conn.
- Porter-Cable Machine Co., Syracuse 4, N. Y.
- Pratt & Whitney Co., Inc., W. Hartford 1, Conn.
- Turchan Follower Machine Co., Inkster, Mich.

SANDING MACHINES

(Wet and Dry)

A. Belt
B. Rotary
C. Vibratory

- Black & Decker Mfg. Co., The, Industrial Div., Towson, Md. (A)
- Boice-Crane Co., Toledo 6, Ohio (A)
- Foredom Electric Co., Inc., Bethel, Conn. (B)
- ★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y. (B)
- Maplewood Companies, Livingston, N. J. (A, B)
- Merit Products, Inc., Los Angeles 16, Calif. (B)
- Nash, J. M., Co. Inc., Milwaukee 45, Wis. (B)
- Skil Corp., Chicago 30, Ill. (A)
- Sommer & Maca Glass Machinery Co., Chicago 50, Ill. (A)
- Union Tool Corp., The, Warsaw, Ind. (A)
- Wysong & Miles Co., Greensboro, N. C. (A, B, C)

SAWING MACHINES

A. Band Sawing
B. Circular Sawing
C. Hack Sawing
D. Jig Sawing
E. Panel Sawing
F. Portable
G. Radial Sawing

- Air Speed Tool Co., Los Angeles 47, Calif. (B, C, E, F)
- Aro Equipment Co., Bryan, Ohio (F)
- Atkins Saw Div., Borg-Warner Corp., Indianapolis 9, Ind. (A, B, C, G)
- Black & Decker Mfg. Co., The, Industrial Div., Towson, Md. (F)
- Boice-Crane Co., Toledo 6, Ohio (A, B, D)
- Buckeye Tools Corp., Dayton, Ohio (F)
- Chicago Pneumatic Tool Co., New York 17, N. Y. (F)
- Carter Products Co., Inc., Grand Rapids 2, Mich. (A)
- ★DoAll Co., The, Des Plaines, Ill. (A)
- ★Falls Engineering & Machine Co., The, Cuyahoga Falls, Ohio (A)
- ★Famco Machine Co., Kenosha, Wis. (A)
- ★Farrel-Birmingham Co., Inc., Ansonia, Conn. (B)
- Foredom Electric Co., Inc., Bethel, Conn. (B)
- Gardner-Denver Co., Quincy, Ill. (F)
- Gaynes Engineering Co., Chicago 12, Ill. (B, E)
- Hendrick Mfg. Corp., Marblehead, Mass. (E)
- Ingersoll-Rand Co., New York 4, N. Y. (F)
- Kohler-Joa Corp., Sheboygan Falls, Wis. (E)
- Mereen Johnson Machine Co., Minneapolis 12, Minn. (B, E)
- Motch & Merryweather Machinery Co., Cleveland 17, Ohio (B)
- Plastics by Chapman, Richmond, Calif. (E)
- Porter-Cable Machine Co., Syracuse 4, N. Y. (A, B, D, F)
- Racine Hydraulics & Machinery, Inc., Racine, Wis. (C)
- Remington Arms Co., Inc., Bridgeport 2, Conn. (F)
- Skil Corp., Chicago 30, Ill. (B, D, F, G)
- Thor Power Tool Co., Aurora, Ill. (F)
- Union Tool Corp., The, Warsaw, Ind. (A, C, G)

TAPPING MACHINES

- Boice-Crane Co., Toledo 6, Ohio
- Hamilton Tool Co., The, Hamilton, Ohio
- ★Mico Instrument Co., Cambridge 38, Mass.
- ★National Automatic Tool Co., Richmond, Ind.
- Procunier Safety Chuck Co., Chicago 6, Ill.
- Snyder Corp., Detroit 7, Mich.

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Supplies

For list of distributors, see p. 1162

ABRASIVE MATERIALS

Composition Materials Co., Inc., New York 36, N. Y.
★Cratex Mfg. Co., Inc., Burlingame, Calif.
Elgin National Watch Co., Abrasives Div., Elgin, Ill.
★Engis Equipment Co., Chicago 5, Ill.
Harrison & Co., Inc., Haverhill, Mass.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
Lea Mfg. Co., The, Waterbury 20, Conn.
Lord Chemical Corp., York, Pa.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Merit Products, Inc., Los Angeles 16, Calif.
Metals Disintegrating Co., Inc., Elizabeth B, N. J.
Norton Co., Worcester 6, Mass.
★Omni Products Corp., New York 16, N. Y.
Pennsalt Chemicals Corp., Philadelphia 2, Pa.
★Raybestos-Manhattan, Inc., Passaic, N. J.
Sirotta, Bernard, Co., Brooklyn 31, N. Y.
Skil Corp., Chicago 30, Ill.
Steelcote Mfg. Co., St. Louis 3, Mo.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.
Ti-Co Industries, Inc., Tipton, Ind.
★Tumb-L-Matic, Inc., Stamford, Conn.
United Laboratories Co., Linden, N. J.
Wheelabrator Corp., Mishawaka, Ind.
White, S. S., Dental Mfg. Co., Industrial Div., New York 16, N. Y.

BAGS, MULTIWALL PAPER

Bemis Bro. Bag Co., St. Louis 2, Mo.
Chase Bag Co., New York 17, N. Y.
Cromwell Paper Co., Chicago 1, Ill.
Equitable Paper Bag Co., Inc., Long Island City 1, N. Y.
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio
Owens-Illinois Glass Co., Multiwall Bag Div., Toledo 1, Ohio

BAGS, PACKAGING

Austin Industries, Inc., Marlboro, Mass.
Bemis Bro. Bag Co., St. Louis 2, Mo.
Canton Containers, Inc., Canton 7, Ohio
Chase Bag Co., New York 17, N. Y.
Cromwell Paper Co., Chicago 1, Ill.
Crystal-X Corp., Lenni Mills, Pa.
Equitable Paper Bag Co., Inc., Long Island City 1, N. Y.
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio
Gaylord Container Corp., St. Louis 2, Mo.
Jacobson, S. I., Mfg. Co., Chicago 5, Ill.
Kehr Products Co., Philadelphia 8, Pa.
Lamex, Inc., Norcross, Ga.
Lawrence Packaging Supply Co., Newark 4, N. J.
Polo Plastics Co., Milwaukee 12, Wis.
Reynolds Plastics, Inc., Walled Lake, Mich.

BAGS, VACUUM AND PRESSURE

Airconductors, Gardena, Calif.
Cuming, M. A., & Co., Inc., New York 12, N. Y.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas.
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio
Reynolds Plastics, Inc., Walled Lake, Mich.
Spartan Products Co., Los Angeles 63, Calif.

BEARINGS

Jodee Plastics, Inc., Brooklyn 8, N. Y.
Laminated Sheet Products Corp., Norwood, Mass.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Polymer Corp. of Pennsylvania, Reading, Pa.
Polypenco, Inc., Reading, Pa.
★Reliable Rubber & Plastic Machinery Co., Inc., N. Bergen, N. J.
Rollway Bearing Co., Inc., Syracuse 4, N. Y.
Timken Roller Bearing Co., The, Canton 6, Ohio

BELTS, BANDS AND SPECIALTIES, ABRASIVE

Armour & Co., Armour Alliance Industries, Alliance, Ohio
★Dayton Rubber Co., The, Dayton, Ohio
Houghton, E. F., & Co., Philadelphia 33, Pa.
Skil Corp., Chicago 30, Ill.
United Laboratories Co., Linden, N. J.

BELTS, STAINLESS STEEL

Metalsmiths, Orange, N. J.
Pyramid Screen Corp., Brookline 46, Mass.

BOXES, CORRUGATED AND SOLID FIBRE

Chemtron Fiber Glass Co., El Monte, Calif.
Federal Container Corp., Minneapolis 22, Minn.
Gaylord Container Corp., St. Louis 2, Mo.
General Box Co., DesPlaines, Ill.
Greif Bros. Cooperage Corp., The, Lindenhurst, N. Y.
Hankins Container Co., Div. of The Flintkote Co., Cleveland 35, Ohio
Hinde & Dauch Div., West Virginia Pulp & Paper Co., Sandusky, Ohio
Inland Container Corp., Indianapolis 6, Ind.
Owens-Illinois Glass Co., Paper Products Div., Toledo, 1 Ohio
River Raisin Paper Co., Monroe, Mich.
Southwestern Plastics, Inc., Houston 36, Texas
Tri-Wall Containers, Inc., New York 14, N. Y.
U. S. Corrugated-Fibre Box Co., The, Indianapolis 7, Ind.

BOXES, TOTE

American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J.
Bricmar Mfg. Corp., New York, N. Y.
Chemtron Fiber Glass Co., El Monte, Calif.
★Colonial Kolonite Co., Chicago, Ill.
Contour Packaging Co., Philadelphia 27, Pa.
Convoy, Inc., Canton 6, Ohio
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
Dura Plastics of New York, Inc., New York 16, N. Y.
Electro Plastics Corp., Dallas 7, Texas
Fabri-Form Co., The, Byesville, Ohio
Federal Container Corp., Minneapolis 22, Minn.
Hawley Products Co., St. Charles, Illinois
Hinde & Dauch Div., West Virginia Pulp & Paper Co., Sandusky, Ohio
Jay Moulding Corp., Cohoes, N. Y.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
Modern Plastics, Miami 42, Fla.
Reynolds Plastics, Inc., Walled Lake, Mich.
Southwestern Plastics, Inc., Houston 36, Texas
Zenith Plastics of Michigan, Inc., Ypsilanti, Mich.

BUFFING AND POLISHING COMPOUNDS

American Products Mfg. Co., New Orleans 18, La.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Composition Materials Co., Inc., New York 36, N. Y.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
Elgin National Watch Co., Abrasives Div., Elgin, Ill.
★Engis Equipment Co., Chicago 5, Ill.
Fisher Scientific Co., Pittsburgh, Pa.
Harrison & Co., Inc., Haverhill, Mass.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
Lea Mfg. Co., The, Waterbury 20, Conn.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Micron Specialties Co., Chicago 39, Ill.
★Omni Products Corp., New York 16, N. Y.
Siebert, R. R., Co., The, Rochester 4, N. Y.
Sirotta, Bernard, Co., Brooklyn 31, N. Y.
Ti-Co Industries, Inc., Tipton, Ind.
United Laboratories Co., Linden, N. J.
Wilco Co., Los Angeles 23, Calif.

★ Indicates Advertiser

CLAMPS

Detroit Stamping Co., Detroit 3, Michigan
Fisher Scientific Co., Pittsburgh 19, Pa.
★Injection Molders Supply Co., Cleveland 20, Ohio
Lapeer Mfg. Co., Detroit 2, Mich.
Modern Plastics, Miami 42, Fla.
Murray Co., Towson 4, Md.
Tinnerman Products, Inc., Cleveland 1, Ohio

COMPOUNDS

A. Mold Cleaning
B. Pipe Joints
C. Purging

Amco Plastic Materials, Inc., Brooklyn 31, N. Y. (C)
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (B)
Brilhart Plastics Corp., Mineola, N. Y. (A, B)
Brulin & Co., Inc., Indianapolis 7, Ind. (A)
Composition Materials Co., Inc., New York 36, N. Y. (A)
Dennis Chemical Co., St. Louis 3, Mo. (B)
★Gering Products, Inc., Kenilworth, N. J. (C)
★Injection Molders Supply Co., Cleveland 20, Ohio (C)
★Johns-Manville, New York 16, N. Y. (B)
L & P Tool Co., Cincinnati 25, Ohio (C)
★Lake Chemical Co., Chicago 12, Ill. (B)
Oakite Products, Inc., New York 6, N. Y. (A)
Permacel, New Brunswick, N. J. (B)
★Plastic Molders Supply Co., Inc., Fanwood, N. J. (C)
★Reed Plastics Corp., Worcester 8, Mass. (C)
Sirotta, Bernard, Co., Brooklyn 31, N. Y. (A)
Techline Div., Wheelabrator Corp., Vicksburg, Mich. (A)

CUT-OFF WHEELS

Allison-Campbell Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.
Elgin National Watch Co., Abrasives Div., Elgin, Ill.
Foredom Electric Co., Inc., Bethel, Conn.
Meyers, W. F., Co., Inc., Bedford, Ind.
Norton Co., Worcester 6, Mass.
★Raybestos-Manhattan, Inc., Passaic, N. J.

DECALCOMANIAS

Bricmar Mfg. Corp., New York 13, N. Y.
Commercial Decal, Inc., Mt. Vernon, N. Y.
Criterion Decalcomania Co., Inc., New York 17, N. Y.
Electro Plastics Corp., Dallas 7, Texas
Kaumagraph Co., Wilmington 99, Del.
Meyercord Co., The, Chicago 44, Ill.
Topflight Corp., York, Pa.

★ Indicates Advertiser

DIES, SHEETING

Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany
J M C Co., Newark 5, N. J.
★Johnson Mfg. Co., Inc., Chippewa Falls, Wis.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Omni Products Corp., New York, N. Y.
Payne Tool & Engineering Co., The, Springfield, Ohio
Skyline Industries, Titusville, Pa.

DIES, STEEL

A & S Steel Rule Die Corp., New York 2, N. Y.
Able Steel Rule Die Co., New York 12, N. Y.
Accurate Steel Rule Die Mfrs., New York 10, N. Y.
★Acromark Co., The, Elizabeth 4, N. J.
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
Allied Engravers Inc., New York, N. Y.
Atlantic Mfg. Co., Philadelphia 22, Pa.
Cowan Boyden Corp., Providence 9, R. I.
Crucible Steel Co. of America, Pittsburgh 30, Pa.
Daniels-Kummer Engraving Co., Addison, Ill.
Defiance Machine & Tool Co., St Louis 10, Mo.
Dewes Gumbs Die Co., Inc., New York 13, N. Y.
Electro Plastics Corp., Dallas 7, Texas
Heppenstall Co., Pittsburgh 1, Pa.
Independent Die & Supply Co., St. Louis 4, Mo.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Latrobe Steel Co., Latrobe, Pa.
Many, J., & Co., New York 13, N. Y.
Payne Tool & Engineering Co., The, Springfield, Ohio
Plastic Mold Tool & Die Co., Inc., E. Rutherford, N. J.
Sarcol Foundry & Pattern Corp., Chicago 12, Ill.
Skyline Industries, Titusville, Pa.
Sossner Steel Stamps, Inc., New York 13, N. Y.
Western Supplies Co., St. Louis 6, Mo.

DRILLS

Elgin National Watch Co., Abrasives Div., Elgin, Ill.
Foredom Electric Co., Inc., Bethel, Conn.
★Omni Products Corp., New York 16, N. Y.
Star Expansion Co., Mountainville, N. Y.
Super Tool Co., Div. of Van Norman Industries, Detroit 13, Mich.

DRUMS, SHIPPING

A. Fibre
B. Metal

Aluminum Co. of America, Pittsburgh 19, Pa. (B)
Greif Bros. Cooperage Corp., The, Lindenhurst, N. Y. (A, B)
Hawley Products Co., St. Charles, Illinois (A)
Lawrence Packaging Supply Co., Newark 4, N. J. (A, B)
Microcell, Ltd., London W.C. 2, England (A, B)
Owens-Illinois Glass Co., Paper Products Div., Toledo 1, Ohio (A)

ELECTRODES, HIGH-FREQUENCY HEAT SEALING

A & S Steel Rule Die Corp., New York 2, N. Y.
Able Steel Rule Die Co., New York 12, N. Y.
Allied Engravers Inc., New York, N. Y.
★Callanan, J. A., Co., Chicago 6, Ill.
Kabar Mfg. Corp., N. Y. 62, N. Y.
★Mayflower Electronic Devices, Inc., Little Ferry, N. J.
★Omni Products Corp., New York 16, N. Y.
★Peterson, A. W., & Sons Die Co., Inc., New York 12, N. Y.
Reeve Electronics, Inc., Chicago 6, Ill.
★Sealomatic Electronics Corp., Brooklyn 11, N. Y.

EXTRUDER CYLINDERS

★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
Johann Fischer, Maschinenbau, Lohmar, Bez., Cologne, West Germany
Iddon Brothers Ltd., Leyland, Lancashire, England
★Industrial Research Laboratories, Div. of Honolulu Oil Corp., Los Angeles 11, Calif.
J M C Co., Newark 15, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Omni Products Corp., New York, N. Y.
Sawaga Manufacturing Co., Inc., Trinidad, Colo.

EXTRUDER SCREWS

★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
Al-Be Industries, South Gate, Calif.
Iddon Brothers, Ltd., Leyland, Lancashire, England
J M C Co., Newark 5, N. J.
★Johnson Mfg. Co., Inc., Chippewa Falls, Wis.
★Killion Tool & Mfg. Co., Verona, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
★Omni Products Corp., New York, N. Y.
★Peco Machinery Sales (Westminster), Ltd., London, S. W. I., England
Sawaga Mfg. Co., Inc., Trinidad, Colo.
Skyline Industries, Titusville, Pa.
Wayne Machine & Die Co., Passaic, N. J.

FASTENERS

Aluminum Co. of America, Pittsburgh 19, Pa.
Central Screw Co., Chicago 9, Ill.
Flexigrip, Inc., New York 21, N. Y.
Industrial Plastic Fabricators, Norwood, Mass.
Palnut Co., The, Mountainside, N. J.
Parker-Kalon Div., General American Transportation Corp., Clifton, N. J.
Phelps Mfg. Co., The, Westport, Conn.
Pheoll Mfg. Co., Inc., Chicago, Ill.
Standard Screw Co., Bellwood, Ill.
Star Expansion Co., Mountainville, N. Y.
Tinnerman Products, Inc., Cleveland 1, Ohio
United Shoe Machinery Corp., Boston 7, Mass.

FILTER CONE ATTACHMENTS

Electro-Chemical Products, Cleveland 10, Ohio
★Omni Products Corp., New York, N. Y.

FILTERS

Armour & Co., Armour Alliance Industries, Alliance, Ohio
★Dayton Rubber Co., The, Dayton, Ohio
Electro-Chemical Products, Cleveland 10, Ohio
Lincoln Engineering Co., St. Louis 20, Mo.
★Marvel Engineering Co., Chicago 45, Ill.
★Omni Products Corp., New York 16, N. Y.
Perfecting Service Co., Charlotte 6, N. C.
Pyramid Screen Corp., Brookline 46, Mass.

FINISHING COMPOUNDS

Composition Materials Co., Inc., New York 36, N. Y.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
Dennis Chemical Co., St. Louis 3, Mo.
Elgin National Watch Co., Abrasives Div., Elgin, Ill.
Harrison & Co., Inc., Haverhill, Mass.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
National Polymer Products, Inc., Reading, Pa.
★Omni Products Corp., New York 16, N. Y.
Sirotta, Bernard, Co., Brooklyn 31, N. Y.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.
United Laboratories Co., Linden, N. J.

FLEXIBLE MATERIALS FOR MOLDS

Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Chemtron Fiber Glass Co., El Monte, Calif.
Dennis Chemical Co., St. Louis 3, Mo.
Hastings Plastics, Inc., Santa Monica, Calif.
Houghton Laboratories, Inc., Olean, N. Y.
Pasley's Plastic Products, Inc., Atlanta 18, Ga.
Technicraft Co., Boston 34, Mass.

HEATING ELEMENTS

A. Band and Cartridge
B. Infra-red

Chromalox, Inc., Pittsburgh 8, Pa. (A, B)
★General Electric Co., Apparatus Sales Div., Schenectady 5, N. Y. (A, B)
Hotwatt, Inc., Danvers, Mass. (A)
Industrial Heater Co., Inc., New York, N. Y. (A, B)
★Injection Molders Supply Co., Cleveland 20, Ohio (A)
New Jersey Thermex Co., Inc., Harrison, N. J. (A, B)
★Thermel, Inc., Franklin Park, Ill. (A)
Vulcan Electric Co., Danvers 32, Mass. (A)
Watlow Electric Mfg., Co., St. Louis 14, Mo. (A)

HINGES, METAL

★Geissel Mfg. Co., Inc., Hillside, N. J.
★National Lock Co., Rockford, Ill.

HOSE AND TUBING
(Industrial)

A. Flexible Metal
B. Non-Metal

Airconductors, Gardena, Calif. (B)
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (B)
Bemis Bro. Bag Co., St. Louis 2, Missouri (B)
Brilhart Plastics Corp., Mineola, N. Y. (B)
★Callanan, J. A., Co., Chicago 6, Ill. (B)
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas (A, B)
Electro-Chemical Products, Cleveland 10, Ohio (B)
Flexaust Co., The, New York 17, N. Y. (A, B)
Jodee Plastics, Inc., B'klyn., N. Y. (B)
★Johns-Manville, New York 16, N. Y. (B)
Lincoln Engineering Co., St. Louis 20, Mo. (B)
Moore Mfg. Co., Inc., San Francisco 10, Calif. (B)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (B)
★Omni Products Corp., New York 16, N. Y. (A, B)
Packless Metal Hose, Inc., Mt. Vernon, N. Y. (B)
Parker Fittings and Hose Div., Parker-Hannifin Corp., Cleveland 12, Ohio (B)
Perfecting Service Co., Charlotte 6, N. C. (A)
Plastic Extruded Products Co., Elizabeth 1, N. J. (B)
Polymer Corp. of Pa., Reading, Pa. (B)
Polypenco, Inc., Reading, Pa. (B)
Porter, H. K., Co., Inc., Thermoid Div., Philadelphia 24, Pa. (B)
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa. (B)
Resistoflex Corp., Roseland, N. J. (B)
Skyline Industries, Titusville, Pa. (B)
★United States Gasket Co., Plastics Div. of The Garlock Packing Co., Camden, N. J. (B)

INKS FOR PRINTING PLASTICS

★Acheson Dispersed Pigments Co., Unit of Acheson Industries, Philadelphia 3, Pa.
★Acromark Co., The, Elizabeth 4, N. J.
★Apex Machine Co., College Point 56, N. Y.
Atlas Coatings Corp., Long Island City 1, N. Y.
Bemis Bro. Bag Co., St. Louis 2, Missouri
Colora Printing Inks, Inc., Long Island City, N. Y.
Defiance Machine & Tool Co., St. Louis 10, Mo.
General Engineering Co., Radcliffe, Lancashire, England
General Printing Ink Co., Div. of Sun Chemical Corp., New York 17, N. Y.
General Research & Supply Co., Grand Rapids 3, Mich.
Gotham Ink & Color Co., Long Island City 1, N. Y.
★Harwick Standard Chemical Co., Akron 5, Ohio
Interchemical Corp., Printing Ink Div., New York 36, N. Y.
International Eastern Co., New York 1, N. Y.
Markem Machine Co., Keene, N. H.
Palmer, Homer W. & Co., Chicago 22, Ill.
Pasley's Plastic Products, Inc., Atlanta 18, Ga.
Polytex Industrial Finishes Corp., Affiliate of Atlas Coatings Corp., Long Island City, New York
Screen-O-Printer Mfg. Co., Adams, Mass.

INSERTS

Airconductors, Gardena, Calif.
Groov-Pin Corp., Ridgefield, N. J.
Hassall, John, Inc., Westbury, L. I., N. Y.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
Maplewood Companies, Livingston, N. J.
Phelps Mfg. Co., The, Westport, Conn.

JOINTS
(Flexible-Ball, Pipe, Revolving, Swivel)

Barco Mfg. Co., Barrington, Ill.
Chiksan Co., Brea, Calif.
Crawford Fitting Co., Cleveland 10, Ohio
Electro-Chemical Products, Cleveland 10, Ohio
★Liberty Machine Co., Inc., Paterson 4, N. J.
Perfecting Service Co., Charlotte 6, N. C.
Plastiline, Inc., White Plains, N. Y.
Resistoflex Corp., Roseland, N. J.

KNIVES
(For Cutters and Granulators)

★Birbach, L. E., Associates, Inc., Draco Div., Boston (Malden) 48, Mass.
Ferry Machine Co., Kent, Ohio
Firth Sterling, Inc., Pittsburgh 30, Pa.
General Engineering Co., Radcliffe, Lancs., England
Lemmon & Snoap Co., Grand Rapids 9, Mich.
Meyers, W. F., Co., Inc., Bedford, Ind.
Mitts & Merrill, Saginaw, Mich.
Ohio Knife Co., The, Cincinnati 23, Ohio
★Omni Products Corp., New York, N. Y.
★Rainville Co., Inc., The, Garden City, N. Y.
Simonds Saw & Steel Co., Fitchburg, Mass.
★Taylor, Stiles & Co., Riegelsville, N. J.
Victory Carbide Saw & Tool Co., Inc., Antioch, Ill.
★Waldron, John, Corp., New Brunswick, N. J.

LABELS, PRESSURE-SENSITIVE
(Self-Adhesive, for Plastics)

Allen Hollander Co., Inc., New York 51, N. Y.
Avery Label Co., Monrovia, Calif.
Brady, W. H., Co., Milwaukee 9, Wis.
Brewster Enterprises, Inc., Rochester 9, N. Y.
Connecticut Hard Rubber Co., New Haven 10, Conn.
Criterion Decalcomania Co., Inc., New York 17, N. Y.
Dennison Mfg. Co., Framingham, Mass.
Ever Ready Label Corp., Belleville 9, N. J.
Fasson Products, Painesville, Ohio
G & S Label Corp., New York 1, N. Y.
Kleen-Stik Products, Inc., Chicago 31, Ill.

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Labelon Tape Co., Inc., Rochester 9, N. Y.
Printon Corp., New York 10, N. Y.
Screen-O-Printer Mfg. Co., Adams, Mass.
Slomons Laboratories, Inc., Long Island City 1, N. Y.
Tompkins' Label Service, Philadelphia 34, Pa.
Topflight Corp., York, Pa.
Weber Marking Systems, Inc., Mt. Prospect, Ill.

LAMPS

(See also Driers and Preheaters, p. 1118)

A. Infra-red
B. Ultraviolet

Cleveland Process Corp., Cleveland, Ohio (A)
Fisher Scientific Co., Pittsburgh 19, Pa. (A)
★Lawter Chemicals, Inc., Chicago 45, Ill. (B)
Miskella Infra-Red Co., Inc., The, Cleveland 4, Ohio (A)
★Wiegand, Edwin L., Co., Pittsburgh 8, Pa. (A)

MASKING PAPER AND TAPE

Bemis Bro. Bag Co., St. Louis 2, Mo.
Brady, W. H., Co., Milwaukee 9, Wis.
Brewster Enterprises, Inc., Rochester 9, N. Y.
★Callanan, J. A., Co., Chicago 6, Ill.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
★Johns-Manville, New York 16, N. Y.
Permacel, New Brunswick, N. J.
Sawaya Mfg. Co., Inc., Trinidad, Colo.
Technical Tape Corp., New Rochelle, N. Y.

MATERIALS FOR HOBS AND MOLDS

(Beryllium, Steel, etc.)

A. Gypsum
B. Metal
C. Plastic

Accurate Match Plate Co., Inc., Chicago 12, Illinois (B)
Allegheny Ludlum Steel Corp., Pittsburgh 22, Pa. (B)
★Bestwall Gypsum Co., Ardmore, Pa. (A)
Bethlehem Steel Co., Bethlehem, Pa. (B)
Brilhart Plastics Corp., Mineola, N. Y. (B, C)
Brush Beryllium Co., The, Cleveland 3, Ohio (B)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (C)
Carpenter Steel Co., The, Reading, Pa.
Cerro de Pasco Sales Corp., New York 22, N. Y.
Crucible Steel Co. of America, Pittsburgh 30, Pa.
Damen Tool & Engineering Co., Inc., Chicago 31, Ill.
Dennis Chemical Co., St. Louis 3, Mo.
Heppenstall Co., Pittsburgh 1, Pa. (B)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (C)
★Newbury Industries, Inc., Newbury, Ohio
★Standard Tool Co., Leominster, Mass. (B)
★United States Gypsum Co., Chicago 6, Ill. (A, C)
Vanadium-Alloys Steel Co., Latrobe, Pa. (B)

MOLD RELEASE AGENTS

(Mold Lubricants)

★Antara Chemicals, Sales Div. of General Aniline & Film Corp., New York 14, N. Y.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
B. B. Chemical Co., Cambridge 39, Mass.
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, West Germany
Biggs, Carl H., Co., Inc., Santa Monica, Calif.
★Borco Chemicals, Inc., Chicago 41, Ill.
Brulin & Co., Inc., Indianapolis 7, Ind.
Chase Chemical Corp., Pittsburgh, Pa.
Chemical & Engineering Associates, Upper Darby, Pa.
★Chemical Development Corp., Danvers, Mass.
Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif.
★Chemische Werke Hüls, A.G., Marl (Kreis Recklinghausen), West Germany
Chemtron Fiber Glass Co., El Monte, Calif.
Dennis Chemical Co., St. Louis 3, Mo.
★Devcon Corp., Danvers, Mass.
★Dow Chemical Co., The, Midland, Mich.
Dow Corning Corporation, Midland, Michigan
★du Pont de Nemours, E. I., & Co., Inc., Wilmington 98, Del.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany
★Ferro Corp., Color Div., Cleveland 5, Ohio
★Fine Organics, Inc., Lodi, N. J.
Garan Chemical Corp., Gardena, Calif.
General Electric Co., Silicone Products Dept., Waterford, N. Y.
★General Mills, Inc., Oilseeds Div., Minneapolis 26, Minn.
Harms, Perc. E., Co., Northfield, Ill.
★Harwick Standard Chemical Co., Akron 5, Ohio
Hastings Plastics, Inc., Santa Monica, Calif.
★Hayden Mica Co., Inc., Wilmington, Mass.
Houghton, E. F. & Co., Philadelphia 33, Pa.
Houghton Laboratories, Inc., Olean, N. Y.
Industrial & Domestic Silicones, Reseda, Calif.
★Injection Molders Supply Co., Cleveland 20, Ohio
Kenwood Plastics, Washington 6, D. C.
Koppers Co., Inc., Chemicals & Dyestuffs Div., Pittsburgh 19, Pa.
Lakeside Plastics Corp., Oshkosh, Wis.
Lami-Plast Products Co., Tampa 3, Fla.
★Lanair Co., Chicago 10, Ill.
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass.
Lebec Chemical Corp., Paramount, Calif.
Lunn Laminates, Inc., Huntington Station, N. Y.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Magnolia Plastics, Inc., Chamblee, Ga.
Mallinckrodt Chemical Works, St. Louis 7, Mo.
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y.
Merix Chemical Co., Chicago 49, Ill.
Midland Adhesive & Chemical Corp., Ferndale 20, Mich.
Mitchell Rand Mfg. Corp., New York 7, N. Y.
Mel Rez Div., American Petrochemical Corp., Minneapolis 18, Minn.
Oakite Products, Inc., New York 6, N. Y.
★Omni Products Corp., New York, N. Y.
Onyx Oil & Chemical Co., Jersey City 2, N. J.
Optics Manufacturing Corp., Philadelphia 34, Pa.
Para Products Div., Foundry Rubber, Inc., Washington 16, D. C.
Pennsylvania Refining Co., Cleveland 4, Ohio
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
★Rainville Co., Inc., The, Garden City, N. Y.
Research Sales, Inc., Suffern, N. Y.
Schwartz Chemical Co., Inc., Long Island City 1, N. Y.
Shanco Plastics & Chemicals, Inc., Tonawanda, N. Y.
Smooth-On Mfg. Co., Jersey City, N. J.
Specialty Products Co., Jersey City 2, N. J.
Sprits, Lynbrook, New York
Synthetic Chemicals, Inc., Paterson 4, N. J.
★Synthetic Products Co., Cleveland 12, Ohio
Technicraft Co., Boston 34, Mass.
★Thoreson-McCosh, Inc., Detroit, Mich.
Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York, N. Y.
Union Carbide Corp., Silicones Div., New York 17, N. Y.
★United States Gypsum Co., Chicago 6, Ill.
★Whittaker, Clark & Daniels, Inc., New York 7, N. Y.
★Witco Chemical Co., Inc., New York 17, N. Y.

MOLDS, MATERIALS FOR

(See Material for Molds, above)

OIL, HEAT TRANSFER AND HYDRAULIC

★Dow Chemical Co., The, Midland, Mich.
Dow Corning Corp., Midland, Mich.
Farbenfabriken-Bayer, A.G., Leverkusen, West Germany
Houghton, E. F., & Co., Philadelphia 33, Pa.
Pennsylvania Refining Co., Cleveland 4, Ohio
Texaco, Inc., N. Y. 17, N. Y.
Union Carbide Chemicals Co., Div. of Union Carbide Corp., New York, N. Y.
Union Carbide Corp., Silicones Div., New York 17, N. Y.
Union Oil Co. of California, Los Angeles 54, Calif.
★Wiegand, Edwin L., Co., Pittsburgh 8, Pa.

PACKING, HYDRAULIC

Doré, John L., Company, Houston 7, Texas
Houghton, E. F., & Co., Philadelphia 33, Pa.
★Johns-Manville, New York 16, N. Y.
Microcell, Ltd., London W.C. 2, England

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Raybestos-Manhattan, Inc., Passaic, N. J.
★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa.
★United States Gasket Co., Plastics Div. of The Garlock Co., Camden, N. J.

PARTITIONS, PACKAGING

Acme Partition Co., Newark, N. J.
Balsa Ecuador Lumber Corp., New York 36, N. Y.
Convoy, Inc., Canton 6, Ohio
Hankins Container Co., Div. of The Flintkote Co., Cleveland 35, Ohio
Hawley Products Co., St. Charles, Ill.
Hinde & Dauch Div., West Virginia Pulp & Paper Co., Sandusky, Ohio
Microcell, Ltd., London W.C. 2, England
Peter Partition Corp., Bklyn., N. Y.
Plastofilm, Inc., Wheaton, Ill.

PROTECTIVE HAND LOTION

★Vanfaire Co., N. Hollywood, Calif.

RELEASE PAPERS

Cromwell Paper Co., Chicago 1, Ill.
Daubert Chemical Co., Chicago 38, Ill.
Fasson Products, Painesville, Ohio
Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass.
★Omni Products Corp., New York 16, N. Y.
Paterson Parchment Co., Bristol, Pa.
★Rhinelander Paper Co., Div. of St. Regis Paper Co., Rhinelander, Wis.
★Riegel Paper Corp., New York 17, N. Y.

ROLL LEAF

(Stamping Foil)

★Ackerman Gould Co., Oceanside, N. Y.
★Acromark Co., The, Elizabeth 4, N. J.
All Purpose Roll Leaf Corp., Paramus, N. J.
★Apex Machine Co., College Point 56, N. Y.
Defiance Machine & Tool Co., St. Louis 10, Mo.
★Gane Bros. & Lane, Inc., Chicago 7, Ill.
★General Roll Leaf Mfg. Co., Elmhurst 73, N. Y.
Griffin, Campbell, Hayes, Walsh, Inc., New York 10, N. Y.
★Halvorfold Kwikprint Co., Jacksonville, Fla.
Hastings & Co., Inc., Philadelphia, Pa.
Hummel Chemical Co., Inc., New York 6, N. Y.
★Olsenmark Corp., New York 13, N. Y.
★Omni Products Corp., New York 16, N. Y.
★Peerless Roll Leaf Co. Inc., Union City, N . J.
Printon Corp., New York 10, N. Y.
Superior Roll Leaf Mfrs., Inc., Hackensack, N. J.
Swift, M., & Sons, Inc., Hartford 1, Conn.
Timadco, Inc., Mineola, N. Y.

ROLLERS, FOR ROLLER COATING

★Apex Machine Co., College Point 56, N. Y.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Cylinder Mfg. Co., Hawthorne, N. J.
★Dayton Rubber Co., The, Dayton, Ohio
★Finish Engineering Co., Inc., Erie, Pa.

★ Indicates Advertiser

International Engraving Corp., Cedar Grove, N. J.
Modern Engraving & Machine Co., Hillside, N. J.
Pamarco, Inc., Roselle, N. J.
Rotobond Co., Bound Brook, N. J.
Shannon, Alexander J., Co., The, New York 38, N. Y.
Stowe-Woodward, Inc., Newton Upper Falls 64, Mass.
Weiss, Albert, & Co., Brooklyn 32, N. Y.

SAW BLADES

Elgin National Watch Co., Abrasives Div., Elgin, Ill.
Ferry Machine Co., Kent, Ohio
Forrest Mfg. Co., Inc., Rutherford, N. J.
Lemmon & Snoap Co., Grand Rapids 9, Mich.
Meyers, W. F., Co., Inc., Bedford, Ind.
Radial Cutter Mfg. Corp., Elizabeth 4, N. J.
Simonds Saw & Steel Co., Fitchburg, Mass.
Starlite Industries, Inc., Philadelphia, Pa.
Victory Carbide Saw & Tool Co., Inc., Antioch, Ill.

SCREWS

(Drive, Thread Cutting, Thread Forming, etc.)

Central Screw Co., Chicago 9, Ill.
Electro-Chemical Products, Cleveland 10, Ohio
Hassal, John, Inc., Westbury, L. I., N. Y.
★National Lock Co., Rockford, Ill.
Pheoll Mfg. Co., Inc., Chicago, Ill.
Southern Screw Co., Statesville, N. C.
Standard Screw Co., Bellwood, Ill.

SCREWS, EXTRUDER

(See Extruder Screws, above)

SPRAY MASKS

★Akron Preform Mold Co., Cuyahoga Falls, Ohio
Arnhurt Associate Engineers, New York, N. Y.
Clear View Plastics Corp., Poplar Bluff, Mo.
★Conforming Matrix Corp., Toledo 2, Ohio
★Finish Engineering Co., Inc., Erie, Pa.
Fiore, William M., Inc., Brooklyn 32, N. Y.
Houghton Laboratories, Inc., Olean, N. Y.
★Jay Co., T. V., Chicago 18, Ill.
★Matthews, James H., & Co., Pittsburgh 13, Pa.
Paragon Plastic Corp., New York 12, N. Y.
Planet Plating Co., Inc., Brooklyn 22, N. Y.
Premier Plastics Co., Milwaukee 4, Wis.
Reinhardt Plastics Co., Denver 2, Colo.
Ren Plastics, Inc., Lansing 9, Mich.
Servwell Products Co., Cleveland 3, Ohio
Staff Die Cutting Co., New York 10, N. Y.
★Thierica Studio, Inc., Grand Rapids 5, Mich.
Timely Products Co., Des Moines 15, Iowa
Topflight Corp., York, Pa.

SPRAY PAINTING FIXTURES

Arnkurt Associate Engineers, New York 1, N. Y.
Atlantic Mfg. Co., Philadelphia 22, Pa.
Bricmar Mfg. Corp., New York 13, N. Y.
Cerro de Pasco Sales Corp., New York 22, N. Y.
★Conforming Matrix Corp., Toledo 2, Ohio
Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio
★Finish Engineering Co., Inc., Erie, Pa.
Fiore, William M., Inc., Brooklyn 32, N. Y.
★Jay Co., T. V., Chicago 18, Ill.
Maplewood Companies, Livingston, N. J.
Plastic Corp. of Chicago, Lyons, Ill.
Screen-O-Printer Mfg. Co., Adams, Mass.
★Sepanski & Associates, Grand Rapids 5, Mich.
★Thierica Studio, Inc., Grand Rapids 5, Mich.

TOOLS, CARBIDE TIPPED

Allegheny Ludlum Steel Corp., Pittsburgh 22, Pa.
Elgin National Watch Co., Abrasives Div., Elgin, Ill.
Firth Sterling, Inc., Pittsburgh 30, Pa.
Kramer, H. W., Co., Inc., Richmond Hill 18, N. Y.
Lemmon & Snoap Co., Grand Rapids 9, Mich.
Meyers, W. F., Co., Inc., Bedford, Ind.
North American Products Corp., Jasper, Ind.
Pratt & Whitney Co., Inc., W. Hartford 1, Conn.
Starlite Industries, Inc., Philadelphia 39, Pa.
Super Tool Co., Div. of Van Norman Industries, Detroit 13, Mich.
Victory Carbide Saw & Tool Co., Inc., Antioch, Ill.

TUMBLING MEDIA

(Abrasive Compounds, and Pegs)

Agrashell, Inc., Los Angeles 22, Calif.
Composition Materials Co., Inc., New York 36, N. Y.
Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio
Lord Chemical Corp., York, Pa.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Norton Co., Worcester 6, Mass.
Siebert, R. R., Co., The, Rochester 4, N. Y.
Sirotta, Bernard, Co., Brooklyn 31, N. Y.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.
Ti-Co Industries, Inc., Tipton, Ind.
★Tumb-L-Matic, Inc., Stamford, Conn.
United Laboratories Co., Linden, N. J.

TUNGSTEN COILS AND STRANDS

★General Electric Co., Lamp Metals & Components Dept., Cleveland, Ohio
★Kassel Export Co., Englewood, N. J.
★NRC Equipment Corp., Newton 61, Mass.
★Sylvania Electric Products Inc., Chemical & Metallurgical Div., Towanda, Pa.

VALVES

- A. *Diaphragm*
- B. *Hydraulic*
- C. *Pneumatic*

Airmatic Valve, Inc., Cleveland 9, Ohio (A)
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J. (A, B)
American Instrument Co., Inc., Silver Spring, Md. (C)
Bellows Co., The, Akron 9, Ohio (B, C)
Edwards High Vacuum, Inc., Niagara Falls, N. Y. (A)
Goodrich, B. F., Industrial Products Co., Marietta, Ohio (A, B, C)
Hanna Engineering Works, Chicago 22, Ill. (B, C)
Hannifin Co., Div. of Parker-Hannifin Corp., Des Plaines, Ill. (C)
High Vacuum Equipment Corp., Hingham, Mass. (A)
Industrial Plastic Fabricators, Norwood, Mass. (A)
Leslie Co., Lyndhurst, N. J. (A, B, C)
Powers Regulator Co., The, Skokie 34, Ill. (A)
Sawaya Mfg. Co., Inc., Trinidad, Colo. (B)
★Sinclair-Collins Valve Co., The, Div. of International Basic Economy Corp., Akron 11, Ohio (A)
Skyline Industries, Titusville, Pa. (A)
Taylor-Emmett Controls, Inc., Akron 19, Ohio (A)
Valvair Corp., Akron 3, Ohio (A, B, C)

WIPE-IN PAINTS

Keeler & Long Inc., Waterbury, Conn.
★Lake Chemical Co., Chicago 12, Ill.
Markal Co., Chicago 12, Ill.
★Mico Instrument Co., Cambridge, Mass.

Specialized Services

ABRASIVE FORMING

Brooklyn Plastic Co., Inc., Brooklyn 1, N. Y.
Chemtron Fiber Glass Co., El Monte, Calif.
Chicago Wood & Plastic Products, Chicago 41, Ill.
Curry Arts, Scranton 9, Pa.
★Engineering Laboratories, Inc., Pompton Lakes, N. J.
★Orange Products, Inc., Orange, N. J.

APPLIED DECORATIONS ON PLASTICS

- A. *Barrel Plating*
- B. *Design Plating*
- C. *Dyeing*
- D. *Engraving*
- E. *Etching*
- F. *Flocking*
- G. *Hot Stamping*
- H. *Marking*
- I. *Metal Inlaying*
  Metallizing (See below)
- J. *Paint Spraying*
- K. *Silk Screening*

A.A.A. Plastic Co., New York 17, N. Y. (D, F, G, H, K)
A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash. (C, D, K)
A.B.S. Mfg. Co., Inc., New York 11, N. Y. (H)
Aacon Industries, Inc., Brooklyn 24, N. Y. (A, B, C, D, E, F, G, H, I, J, K)
Accurate Gold Stamping Co., Inc., New York 11, N. Y. (G)
★Ace Plastic Co., Jamaica 35, N. Y. (G)
Ace Plastic Molding Corp., Long Island City 1, N. Y. (D)
Acme Laminating & Plastics Co., Inc., Detroit, Mich. (F, G, H, J, K)
★Acromark Co., The, Elizabeth 4, N. J. (D, G, H)
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio (J)
Alda Plastics Inc., New York 13, N. Y. (D, E, K)
Allegheny Plastics, Inc., Coraopolis, Pa. (D)
Allied Plastics Supply Co., New York 38, N. Y. (D, E, G, H)
All Plastics Corp., Avon-By-The-Sea, N. J. (G, K)
Allied Plasti-Lite Enterprises, Inc., St. Louis 4, Mo. (G)
American Plasticraft Co., New York 61, N. Y. (G, H)
Ameriplastic Co., The, Flint 7, Mich. (D, G, H, J, K)
★Amos Molded Plastics Div., Amos-Thompson Corp., Edinburg, Ind. (G, H, J, K)
Aquador Plastics, Inc., Brooklyn 32, N. Y. (G, K)
Art Decorating Co., North Bergen, N. J. (D, G, H, K)
Art Plastics Mfg. Co., Los Angeles 21, Calif. (G)
Artmor Plastics Corp., Cumberland, Md. (D, G)
Atlantic Plastics, Inc., Stamford, Conn. (G)
Atlas Plastics, Inc., Little Ferry, N. J. (G, K)
Augusta Plastics, Inc., Bronx 69, N. Y. (B, H, J, K)
Bedford Products, Inc., Roanoke, Va. (G)
Berkander, George F., Inc., Providence 7, R. I. (C, J)
Bernard Plastics Molding Corp., Long Island City 1, N. Y. (G, H, J, K)
Berton Plastics, Inc., New York 3, N. Y. (D, K)
★Blackhawk Molding Co., Inc., Addison, Ill. (G)
★Blank, Arthur, & Co., Inc., Boston 15, Mass. (K)
Bolling Industries, Inc., Scranton 5, Pa. (D, G, H, J, K)
Borkland Mfg. Co., Marion, Ind. (H, J, K)
Bricmar Mfg. Corp., New York 13, N. Y. (D, G, J, K)
Bridgeport Moulded Products, Inc., Fairfield, Conn. (H, J)
Brilhart Plastics Corp., Mineola, N. Y. (C, G, H)
Brockton Plastics, Inc., Brockton, Mass. (H, K)
Campro Co., The, Canton 1, Ohio (G, H, J, K)
★Capitol Plastics Co., Lansing, Mich. (J)
★Carroll, J. B., Co., Chicago 12, Ill. (G, K)
Chaney Plastic Molding Co., Denver 16, Colo. (G)
Chatelain Plastics, Findlay, Ohio (D, G, K)
Claremould Plastics Co., Newark 5, N. J. (D, E, G, H, J, K)
Clear View Plastics Corp., Poplar Bluff, Mo. (D, F, G, J)
Colorite Industrial Dyers, New York 18, N. Y. (C)
Colts Plastics Co., Inc., N. Grosvenordale, Conn. (G, K)
Colvin-Friedman Co., Springfield, N. J. (G, H, K)
Commercial Plastics Co., Chicago 14, Ill. (G)
★Como Plastics, Inc., Columbus, Ind. (G, H, I, J, K)
★Conforming Matrix Corp., Toledo 2, Ohio (J, K)
Conn-Craft Co., Waterbury 5, Conn. (D, G, H)
Conroc of Monterey, Monterey, Calif. (H)
Consolidated Plastics & Mfg. Co., Chicago 10, Ill. (D, G, J, K)
Cowan Boyden Corp., Providence 9, R. I. (G, J, K)
Crystal Plastic, Inc., Brooklyn 5, N. Y. (D, K)
Curry Arts, Scranton 9, Pa. (G, J, K)
D & G Plastics Co., Kent, Ohio (G, H)
Daniels-Kummer Engraving Co., Addison, Ill. (D)
★Davies, Harry, Molding Co., Chicago 10, Ill. (G, H)
Defiance Machine & Tool Co., St. Louis 10, Mo. (D, H)
Delkay Plastics Corp., Gardena, Calif. (H)
Double D Plastics, Greenville, Mich. (J, K)
Dumais, Joseph F., Co., Fall River, Mass. (G)
Dura Plastics of New York, Inc., New York 16, N. Y. (D, K)
Eagle Molding Corp., Brooklyn 15, N. Y. (K)
Eagle Roll Leaf Stamping Co., Brooklyn 15, N. Y. (D, G, H, K)
Edwards High Vacuum, Inc., Niagara Falls, N. Y. (I)
Electric Auto-Lite Co., The, Toledo 1, Ohio (B, G, H, J)
Electrochemical Industries, Inc., Worcester 3, Mass. (A)
★Emeloid Co., Inc., The, Hillside 5, N. J. (D, F, G, H, J, K)
★Engineered Plastics, Inc., Gibsonville, N. C. (D, H, K)

★ Indicates Advertiser

Evans-Zeier Plastic Co., Madison 4, Wis. (D, H, K)
Excel Plastic Mfg. Corp., New York 32, N. Y. (J, K)
F & F Mold & Die Works, Inc., Dayton, Ohio (J, K)
Fabri-Form Co., The, Byesville, Ohio (D)
Fabri-Kal Corp., Kalamazoo, Mich. (G, J, K)
Fawn Plastics Co., Inc., Timonium, Md. (D, G, H, J, K)
Federal Tool Corp., Chicago 45, Ill. (G, K)
Fiberform, Inc., Oconomowoc, Wis. (K)
Fiore, William M., Inc., Brooklyn 32, N. Y. (J, K)
Formica Corp., The, Cincinnati 32, Ohio (D, E, I)
Franklin Fibre-Lamitex Corp., Wilmington 99, Del. (D, H, I, J, K)
Fried Novelties, Brooklyn 19, N. Y. (G)
Futura, Inc., Chicago 8, Ill. (C, I, J, K)
G. M. C. Process Corp., New York 3, N. Y. (B)
Garray Plastics, Inc., Kearny, N. J. (G, I, J, K)
★General American Transportation Corp., Plastics Div., Chicago 90, Ill. (J, K)
★General Industries Co., The, Elyria, Ohio (G, H, J, K)
General Machine & Tool Works, Walled Lake, Mich. (A, B, C, D, E, F, H, G, I, J, K)
★General Plastics Corp. Marion, Ind. (J, K)
General Research & Supply Co., Grand Rapids 3, Mich. (K)
Gits, J. P., Molding Corp., Chicago 44, Ill. (G, J, K)
Gotham Plastics Corp., Bronx 51, N. Y. (G, J, K)
Hanley Plastics Co., St. Louis 17, Mo. (J)
Har-E-Dan Engravers, Brooklyn 8, N. Y. (D, G, H, J, K)
Harva Co., Inc., The, Schoharie, N. Y. (D, H, J, K)
Hastings & Co., Inc., Philadelphia 3, Pa. (C, I)
Hermes Engravers, Inc., New York 11, N. Y. (D, H)
Hero Mfg. Co., Inc., Middleboro, Mass. (C, H)
★Ideal Plastics, Div. of Ideal Toy Corp., Hollis 23, N. Y. (G)
Imperial Industries, Inc., Wayne, Mich. (D)
Industrial Marking Equipment Co., Inc., Brooklyn 8, N. Y. (H)
Industrial Sales Engineers, New York 17, N. Y. (D, E, F, G, H, K)
Insulating Fabricators of New England, Inc., Watertown 72, Mass. (D, H, K)
International Eastern Co., New York 1, N. Y. (H)
International Plastic Co., New York 29, N. Y. (H, J, K)
Jacobson, S. I., Mfg. Co., Chicago 5, Ill. (G, K)
Jamison Plastic Corp., N. Bellmore, L. I., N. Y. (B, C, D, G, H, J, K)
Jay Moulding Corp., Cohoes, N. Y. (K)
Jodee Plastics, Inc., Brooklyn 8, N. Y. (D, G, H, J, K)
Joliet Plastic, Inc., Joliet, Ill. (G)
Kaufman Glass Co., Plastic Div., Wilmington 99, Del. (D, E, K)
Kaumagraph Co., Wilmington 99, Del. (K)
Kent Plastics Corp., Evansville 10, Ind. (G, J, K)
Kerrco Products, Lincoln 7, Neb. (D, G, H, J, K)
★Kingman, E. B., Co., Leominster, Mass. (G, J, K)
Kuhlman Plastics Co., Inc., Kansas City, Mo. (G, J, K)
Kusan, Inc., Nashville, Tenn. (J, K)
Laminated Sheet Products Corp., Norwood, Mass. (D, G, H, J, K)
Lansky Die Cutting Corp., Brooklyn 15, N. Y. (K)
Libbert Plastics, Inc., Fort Worth 14, Texas (H, I)
★Lincoln Molded Plastics, Inc., Circleville, Ohio (G)
Long, Thomas, J., Inc., Carle Place, N. Y. (D, H, J, K)
Ludascher, William C., Eddington, Pa. (G)
Lustra-Cite Industries, Inc., Brooklyn 11, N. Y. (D, G, J, K)
Madan Plastics, Inc., Cranford, N. J. (C, D, E, F, G, H, J, K)
Maine Molding Products, Boothbay Harbor, Maine (F, J, K)
Majestic Creations, Inc., Woodside 77, N. Y. (K)
Marbek, Inc., Brooklyn 22, N. Y. (I)
Martin, Fair, Boxes, Inc., Concord, N. C. (K)
Mechanical Engraving Co., Inc., New York 68, N. Y. (D, G, H, K)
Midland Coatings, Inc., Minneapolis 13, Minn. (J, K)
Mtchell Plastics, Inc., Owosso, Mich. (G, J, K)
Mitchell's, L. D., Plastic Studio, Pittsburgh 12, Pa. (D)
Modern Engraving & Machine Co., Hillside, N. J. (D, E)
Moldcraft, Inc., Baltimore 11, Md. (G)
Monaplastics, Inc., Georgetown, Conn. (G, J, K)
★Morningstar Corp., The, Cambridge 42, Mass. (G, J)
Motson, J. Frank, Co., Flourtown, Pa. (H, K)
Mueller, Ernest, Los Angeles 36, Calif. (I)
Multicraft, Inc., Hillside, Ill. (G, H, K)
Nashua Corp., Nashua, N. H. (F)
Nichols Products Co. Inc., Moorestown, N. J. (G, I)
Norco Plastic Inc., Milwaukee, Wis. (D, E, G, H, J, K)
North Star Industries, Inc., Hopkins, Minn. (J)
Nosco Plastics, Inc., Erie, Box 269, Pa. (B, C, G, H, J, K)
Olympic Plastics Co. Inc., Los Angeles 16, Calif. (K)
O'Sullivan Rubber Corp., Winchester, Va. (J)
Owens-Illinois Glass Co., Toledo 1, Ohio (E, G, I, J, K)
Paragon Plastic Corp., New York 12, N. Y. (G, J, K)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (H)
Permanent Label Corp., Bloomfield, N. J. (G, H, K)
Perma Seal Plastic Products Co., St. Paul 4, Minn. (G)
Pitman Plastic Products, Inc., Pitman, N. J. (J)
Planet Plating Co. Inc., Bklyn. 22, N. Y. (A, I)
Plast-Ad Mfg. Co., South Bend, Ind. (D, K)
Plastic Art Metallizing Corp., Brooklyn 22, N. Y. (G, K)
Plastic Center, Rochester 4, N. Y. (D)
Plastic Engineering Co. of Tulsa, Tulsa, Okla. (D, F, H, K)
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga. (D, J, K)
Plastic Inlays, Inc., Summit, N. J. (I, J, K)
Plastic Masters, Inc., New Buffalo, Mich. (C, G, H, J)
Plastic Parts Corp., Maumee, Ohio (K)
Plastic Precision Parts Co., Chicago 39, Ill. (H, K)
Plastic Service Corp., New York 10, N. Y. (G, K)
Plastic Suppliers and Manufacturers, Baton Rouge, La. (D, G, K)
Plastiplate Co., Inc., South River, N. J. (A)
Plastics by Chapman, Richmond, Calif. (D, J)
Plastics by Hoover, Huntington, W. Va. (K)
Plastics Industries, Inc., Athens, Tenn. (D, F, G, H, J, K)
Platecraft, Inc., Los Angeles 46, Calif. (A)
Polymer Corp. of Pennsylvania, Reading, Pa. (C)
Polypenco, Inc., Reading, Pa. (C)
Polyplastex United, Inc., Union, N. J. (J, K)
Premier Plastic Mfg. Co., Minneapolis 26, Minn. (D, J, K)
Premier Plastics Co., Milwaukee 4, Wis. (G, H, J, K)
★Premier Vacuum Process Corp., Maspeth 78, N. Y. (C, J)
Printloid, Inc., Long Island City 1, N. Y. (D, G, H, J, K)
Prolon Plastics, Florence, Mass. (J, K)
Pyramid Industrial Finishing Corp., New York 55, N. Y. (C, J)
Pyramid Screen Corp., Brookline 46, Mass. (K)
Rand Rubber Co., Brooklyn 16, N. Y. (K)
Rawsan Corp., Hialeah, Fla. (J)
Rayon Processing Co. of R. I., Pawtucket, R. I. (F)
Reinhardt, J. A., Co., Mountain Home, Pa. (D, G, H, J, K)
Reinhardt Plastics Co., Denver 2, Colo. (D, F, G, H, J)
Reynolds Plastics, Inc., Walled Lake, Mich. (D, G, J, K)
Roltex Process Corp., Roselle, N. J. (C, F)
Romar Plastics, Inc., St. Charles, Ill. (G, H, I, J, K)
Rosbro Plastics Corp., Pawtucket, R. I. (J)
S-K-W Mfg. Co., Chicago 30, Ill. (G, H, I, J, K)
S-L-M Plastics, Avenel, N. J. (K)
Sampson Chemical & Pigment Corp., Chicago 12, Ill. (H, J, K)
Santay Corp., Chicago 24, Ill. (G, I, J, K)
Sawaya Mfg. Co., Inc., Trinidad, Colo. (E, K)
Scheidl Mfg. Co., Copiague, N. Y. (D, H)
Screen-O-Printer Mfg. Co., Adams, Mass. (J, K)
Sealy Plastics Corp., Rockville, Conn. (G)
Sharpe Plastics, Inc., Sudbury, Mass. (D, J, K)
Shasta Mfg. Co., Berkeley Heights, N. J. (G, H)
★Sierra Electric Corp., Gardena, Calif. (D, E, F, H, I, J, K)
★Sillcocks Miller Co., The, Maplewood, N. J. (C, G, H, J, K)
Solar Plastic Products Co., Brooklyn 5, N. Y. (D)
Sossner Steel Stamps, Inc., New York 13, N. Y. (D)
South Salem Studios, South Salem, N. Y. (J, K)
Southeastern Sales Corp., St. Petersburg 13, Fla. (D, K)

★ Indicates Advertiser

Southern Plastic Products Co., Riviera Beach, Fla. (G, H, J, K)
Southwestern Plastics, Inc., Houston 36, Texas (D, E, J, K)
Springfield Fabricators, Inc., Springfield, N. J. (G, H, K)
Springfield Moulders, Inc., Monson, Mass. (H)
Springfield Tool & Die Co., Inc., Springfield, N. J. (D)
Stensgaard, W. L., & Associates, Inc., Chicago 7, Ill. (F, J, K)
Stricker-Brunhaber Corp., New York 10, N. Y. (D)
Sun Plastics, Inc., Cuyahoga Falls, Ohio (G, H)
★Superior Plastics, Inc., Chicago 12, Ill. (A, D, G, H, J, K)
Syracuse Plastic Molders, Syracuse 2, N. Y. (G, K)
Technigraph, Winona, Minn. (K)
Thermold Corp., Manlius, New York (H, J, K)
★Thierica Studio, Inc., Grand Rapids 5, Mich. (B, J, K)
Thomas, Charles W., Inc., Philadelphia 24, Pa. (D, E, F, G, H, J. K)
Thompson Air Plastics, Mineola, N. Y. (G, H)
Tico Plastics, Inc., New York 11, N. Y. (J)
Timely Products Co., Des Moines 15, Iowa (G, J, K)
Transplastics Fabricating Co., Boston 15, Mass. (D, K)
Tri-State Plastic Molding Co., Henderson, Ky. (G, K)
Ultra Plastics, Inc., Philadelphia 30, Pa. (J, K)
United Fabricators & Electronics, Inc., Stillwater, Minn. (H, K)
United Mask & Novelty Co., Inc., Glendale, N. Y. (K)
Usines Gheysen, S .A., Lembecq-Hal, Belgium (K)
Vac-Art, Inc., Bay City, Mich. (G, J, K)
Vacuum Plastics Corp., Columbus 22, Ohio (J, K)
Valley-National Corp., The, Milldale, Conn. (D, H, K)
Victory Plastics Co., Hudson, Mass. (H, J, K)
Virginia Plak Co., New York 16, N. Y. (G, K)
Vogel Mfg. Co., The, Bridgeport 1, Conn. (H)
Wachter Plastic Co., Sacramento 14, Calif. (D, G, K)
Wama Co., The, Baltimore 2, Md. (D, G, J, K)
Weber Marking Systems, Inc., Mt. Prospect, Ill. (D)
Welch Plastics & Mfg. Co., Inc., Columbus 8, Ohio (G, H, J, K)
Wessel, Stanley, Co., Chicago 11, Ill. (K)
Willson Camera Co., Havertown, Pa. (J, K)
Wolverine Plastics, Inc., Milan, Mich. (J, K)
Zenith Plastics of Michigan, Inc., Ypsilanti, Mich. (D, G, H, J, K)

BLOW MOLDING

A.A.A. Plastic Co., New York 17, N. Y.
A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
Aacon Industries, Inc., Brooklyn 24, N. Y.
Air-Formed Products Corp., Nashua N. H.
Alda Plastics Inc., New York 13, N. Y.
Allied Plastics Supply Corp., New York 38, N. Y.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Barclay Industries Inc., New York, N. Y.
Belon Chemical Co., Inc., Cranston 10, R. I.
Berton Plastics, Inc., New York 3, N. Y.
Blow-O-Matic Corp., The, Bridgeport 7, Conn.
Bricmar Mfg. Corp., New York 13, N. Y.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Campro Co., The, Canton 1, Ohio
Classic Studio, New York 16, N. Y.
Crystal Plastic, Inc., Brooklyn 5, N. Y.
Crystal-X Corp., Lenni Mills, Pa.
★DeWitt Plastics Div., Shoe Form Co., Inc., Auburn, N. Y.
Eisler Engineering Co., Inc., Newark 3, N. J.
Firmaline Products, Inc., Midland Park, N. J.
★Foster Grant Co., Inc., Leominster, Mass.
★Goulding Mfg. Co., Saginaw, Mich.
Harva Co., Inc., The, Schoharie, N. Y.
Industrial Sales Engineers, New York 17, N. Y.
Injection Molding Co., Kansas City 30, Mo.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
Just Plastics, Inc., New York 34, N. Y.
Laminated Sheet Products Corp., Norwood, Mass.
Leedpak, Inc., New York 1, N. Y.
Linehan & Co., Dallas 7, Texas
Lustra-Cite Industries, Inc., Brooklyn 11, N. Y.
Madan Plastics, Inc., Cranford, N. J.
★Mahl Industries, Inc., New York 56, N. Y.
Many, J., & Co., New York 13, N. Y.
Nalge Co. Inc., The, Rochester 2, N. Y.
Northeastern Plastics, Inc., Boston 10, Mass.
Nosco Plastics, Inc., Box 269, Erie, Pa.
Olympic Plastics Co. Inc., Los Angeles 16, Calif.
Owens-Illinois Glass Co., Toledo 1, Ohio
Pam Co., Portland 9, Ore.
Peerless Plastics, Culver City, Calif.
Plastic Engineering Co., Pawtucket, R. I.
Plasticite Corp., New York 51, N. Y.
Plastics Center of Texas, San Antonio 4, Texas
Plast-O-Matic Corp., Leominster, Mass.
★Plax Corp., Hartford 1, Conn.
Reynolds Plastics, Inc., Walled Lake, Mich.
Rosbro Plastics Corp., Pawtucket, R. I.
Sajar Plastics, Inc., Middlefield, Ohio
Star Plastic Specialties, Boston 10, Mass.
Tico Plastics, Inc., New York 11, N. Y.
Ultra Plastics, Inc., Philadelphia 30, Pa.
Vantine, Inc., Flushing 54, N. Y.
Wachter Plastic Co., Sacramento 14, Calif.
Woodall Industries, Inc., Detroit 34, Mich.

CASTING

A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
Aacon Industries, Inc., Brooklyn 24, N. Y.
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
Applied Resins Corp., N. Caldwell, N. J.
Argo Plastic Products Co., Cleveland 13, Ohio
Aries Laboratories, Inc., Long Island City, N. Y.
Atkins & Merrill, Inc., Reinforced Plastics Div., Marlboro, Mass.
Atlas Plastics, Inc., Buffalo 10, N. Y.
Atti Engineering Corp., Union City, N. J.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Bacon & Weber, Chicago 22, Ill.
Boonton Molding Co., Boonton, N. J.
Bricmar Mfg. Corp., New York 13, N. Y.
Brilhart Plastics Corp., Mineola, N. Y.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Chemical & Engineering Associates, Upper Darby, Pa.
Chemtron Fiber Glass Co., El Monte, Calif.
Clearfloat, Inc., Attleboro, Mass.
Conneaut Rubber & Plastics Co., Conneaut, Ohio
Conroc of Monterey, Monterey, Calif.
Crucible Steel Co. of America, Pittsburgh 30, Pa.
Crystal-X Corp., Lenni Mills, Pa.
Disogrin Industries, Inc., Mt. Vernon, N. Y.
Distinctive Embedments, Inc., Providence 6, R. I.
Emerson & Cuming, Inc., Canton, Mass.
Fassler, M. J., & Co., Inc., Brooklyn 21, N. Y.
General Machine & Tool Works, Walled Lake, Mich.
Glasflex, Inc., Stirling, N. J.
Gries Reproducer Corp., New Rochelle, N. Y.
Hanley Plastics Co., St. Louis 17, Mo.
★Hartig Extruders Div., Midland-Ross Corp., Mountainside, N. J.
Houghton Laboratories, Inc., Olean, N. Y.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Industrial Sales Engineers, New York 17, N. Y.
International Plastic Co., New York 29, N. Y.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
John Kunst Co., The, New York 7, N. Y.
L & P Tool Co., Cincinnati 25, Ohio
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass.
Leon Chemical Industries, Inc., Warren, Mich.
Lumar Optical Mfg. Co., Inc., Mount Vernon, N. Y.
Lustra-Cite Industries, Inc., Brooklyn 11, N. Y.
Madan Plastics, Inc., Cranford, N. J.
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
L. D. Mitchell's Plastic Studio, Pittsburgh 12, Pa.
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio
Plastex Laminates, Inc., Hialeah, Fla.
Plastic Corp. of Chicago, Lyons, Ill.
Plastic Rotocast Co., Chicago 5, Ill.
Plastics by Hoover, Huntington, W.Va.
Plasti-Skill Co., Corona 68, N. Y.
Quelcor, Inc., Chester, Pa.
Reynolds Plastics, Inc., Walled Lake, Mich.
Sarcol Foundry & Pattern Corp., Chicago 12, Ill.
Schramm Fiberglass Products, Inc., Chicago 18, Ill.
★Sierra Electric Corp., Gardena, Calif.
Sierracin Corp., The, Burbank, Calif.
Skeist & Schwarz Labs., Inc., Newark 2, N. J.

★Indicates Advertiser

★Superior Plastics, Inc., Chicago 12, Ill.
Technicraft Co., Boston 34, Mass.
U. S. Plastic Molding Corp., Wallingford, Conn.
Westech Engineering, Santa Clara, Calif.
Young Development Div., Explosives Dept., Hercules Powder Co., Rocky Hill, N. J.

COATING

A. Dip Coating
B. Extrusion Laminating
C. Flame Spraying
D. Solution Coating
E. Specialized Coating on Equipment
F. Spread Coating

A.A.A. Plastic Co., New York 17, N. Y. (B)
American Agile Corp., Bedford, Ohio (C)
American Combining Corp., Arverne 92, N. Y. (A, D, F)
Aries Laboratories, Inc., Long Island City, N. Y. (A)
Associated Rubber & Plastic Corp., New York 51, N. Y. (D, F)
Atlas Mineral Products Co., Mertztown, Pa. (A)
Atlas Plastics, Inc., Buffalo 10, N. Y. (A)
★Auburn Plastics, Inc., Auburn, N. Y. (B)
Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (A, D, F)
Berkander, George F., Inc., Providence 7, R. I. (A)
Biggs, Carl H., Co., Inc., Santa Monica, Calif. (A)
Bischoff Chemical Corp., Ivoryton, Conn. (A)
Bortman Plastics Co., Boston 11, Mass. (D, F)
Bostrom Corp., Milwaukee 4, Wis. (D)
Brewster Enterprises, Inc., Rochester 9, N. Y. (D, F)
Brilhart Plastics Corp., Mineola, N. Y. (A, D)
Brutier Product Co., Inc., Secaucus, N. J. (D)
Chemical & Engineering Associates, Upper Darby, Pa. (A, D)
Clear View Plastics Corp., Poplar Bluff, Mo. (A)
Coating Products, Inc., Englewood, N. J. (D)
Columbia Mills, Inc., The, Syracuse 1, N. Y. (F)
Columbus Coated Fabrics Corp., Columbus 16, Ohio (D, F)
Contour Packaging Co., Philadelphia 27, Pa. (F)
Cromwell Paper Co., Chicago 1, Ill. (A)
Crowl, Charles, Co., El Monte, Calif. (F)
★Davis, Joseph, Plastics Co., Kearny, N. J. (B)
Electro Plastic Fabrics, Inc., Pulaski, Va. (A, F)
Electro-Technical Products Div., Sun Chemical Corp., Nutley 10, N. J. (A, D)
Endura Corp., Quakertown, Pa. (D)
★Engineered Plastics, Inc., Gibsonville, N. C. (A)
Fabri-Form Co., The, Byesville, Ohio (B)
Falls Hollow Staybolt Co., Cuyahoga Falls, Ohio (D)
Farrington Texol Corp., Walpole, Mass. (D, F)
Fassler, M. J., & Co., Inc., Brooklyn 21, N. Y. (D, F)
Flexcon Co., Spencer, Mass. (D)
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio (A, B, D)
Flexible Products Co., Marietta, Ga. (A)
Franklin Fibre-Lamitex Corp., Wilmington 99, Del. (A)
General Plastics Corp., Paterson, N. J. (E)
Globe Imperial Div., Ainsworth-Precision Castings Co., Rockford, Ill. (A)
Gomar Mfg. Co., Inc., Linden, N. J. (D)
Gordon-Lacey Chemical Products, Inc., Maspeth 78, N. Y. (D, F)
Gusmer, A., Inc., Woodbridge, N. J. (D)
H & R Industries, Nazareth, Pa. (B)
Hanley Plastics Co., St. Louis 17, Mo. (A)
Hastings & Co., Inc., Philadelphia 3, Pa. (D)
Heil Process Equipment Corp., Cleveland 11, Ohio (A, D)
Hero Mfg. Co., Inc., Middleboro, Mass. (A)
Industrial Coatings Co., York, Pa. (A)
Industrial Plastic Coating Corp., Clifton, N. J. (D)
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn. (A)
Industrial Sales Engineers, New York 17, N. Y. (A)
International Plastic Co., New York 29, N. Y. (A)
Jacobson, S. I., Mfg. Co., Chicago 5, Ill. (A, D, F)
Jamestown Finishes, Inc., Jamestown, N. Y. (F)
Joclin Mfg. Co., Wallingford, Conn. (A, D)
Jodee Plastics, Inc., Brooklyn 8, N. Y. (B)
L & P Tool Co., Cincinnati 25, Ohio (A)
Lamex, Inc., Norcross, Ga. (B)
Lami-Plast Products Co., Tampa 3, Fla. (A, D)
Landers Corp., The, Toledo 1, Ohio (D, F)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (A, D)
Leon Chemical Industries, Inc., Warren, Mich. (A)
Livingstone Coating Corp., Charlotte 8, N. C. (D)
Lowe Paper Co., Ridgefield, N. J. (B)
Madan Plastics, Inc., Cranford, N. J. (A)
Marbek, Inc., Brooklyn 22, N. Y. (F)
Marmyte Co., Mundelein, Ill. (D, F)
Midland Coatings, Inc., Minneapolis 13, Minn. (A)
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa. (A)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (A, B)
Nashua Corp., Nashua, N. H. (B)
Natvar Corp., Woodbridge, N. J. (A, D)
Novelty Bias Binding Co., Plastics Div., Chelsea, Mass. (F)
O'Sullivan Rubber Corp., Winchester, Va. (B)
Pace, F. C., Co., Grand Rapids, Mich. (A)
Parcloid Chemical Co., Midland Park, N. J. (A)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (A, D)
Pelmor Laboratories, Inc., Newtown, Pa. (A)
Plastex Laminates, Inc., Hialeah, Fla. (F)
Plastic Inlays, Inc., Summit, N. J. (A)
Plastic Papers, Inc., Hicksville, N. Y. (B)
Plastic Suppliers and Manufacturers, Baton Rouge, La. (C)
Plastics Industries, Inc., Athens, Tenn. (A)
Plectron Corp., Overton, Neb. (A)
Polykote, Inc., Cleveland 3, Ohio (A, F)
★Polymer Corp., The, Reading, Pa. (A)
Polyplastex United, Inc., Union, N. J. (A, D, F)
★Premier Vacuum Process Corp., Maspeth 78, N. Y. (A)
Printloid, Inc., Long Island City 1, N. Y. (D, F)
Printon Corp., New York 10, N. Y. (A, D, F)
Pyramid Industrial Finishing Corp., New York 55, N. Y. (A, D)
Pyrotex Co., Inc., Leominster, Mass. (A, D, F)
Quelcor, Inc., Chester, Pa. (A, D, F)
Rand Rubber Co., Brooklyn 16, N. Y. (F)
Randall Mfg. Co., Inc., New York 59, N. Y. (A)
Rawsan Corp., Hialeah, Fla. (A)
Reinhardt Plastics Co., Denver 2, Colo. (A)
★Riegel Paper Corp., New York 17, N. Y. (B, D)
Roltex Process Corp., Roselle, N. J. (F)
★Sandman, Eli, Co., Worcester 9, Mass. (A, D, F)
Santa Barbara Plastics, Sub. of Narmco Industries, Inc., Goleta, Calif. (F)
Sawaya Mfg. Co., Inc., Trinidad, Colo. (A)
Schjeldahl Co., G. T., Northfield, Minn. (B)
Schori Process Corp., Long Island City 1, N. Y. (C)
Seal-Peel, Inc., Royal Oak 3, Mich. (A)
★Southern Plastics Co., Columbia 1, S. C. (B)
Steere Enterprises, Inc., Akron 8, Ohio (A)
Stowe-Woodward, Inc., Newton Upper Falls 64, Mass. (A, D)
Sun Steel Co., Chicago 36, Ill. (D)
Things, Inc., Denver 3, Colo. (A)
Thomas, Charles W., Inc., Philadelphia 24, Pa. (F)
★U. S. Polymeric Chemicals, Inc., Stamford, Conn. (A, D)
Woodall Industries, Inc., Detroit 34, Mich. (B)
Wyatt's Plastics, Inc., Houston 1, Texas (A)

COMPOUNDING

A.A.A. Plastic Co., New York 17, N. Y.
★Acheson Dispersed Pigments Co., Unit of Acheson Industries, Philadelphia 3, Pa.
Alpha Chemical & Plastics Corp., Newark 5, N. J.
Amco Plastic Materials, Inc., Brooklyn 31, N. Y.
★Auburn Plastics, Inc., Auburn, N. Y.
Bamberger, Claude P., Inc., Ridgefield Park, N. J.
Biggs, Carl H., Co., Inc., Santa Monica, Calif.
★Blane Corp., The, Canton, Mass.
Blum, Paul, Co., Buffalo 10, N. Y.
Bortman Plastics Co., Boston 11, Mass.
Bostrom Corp., Mliwaukee 4, Wis.
Brilhart Plastics Corp., Mineola, N. Y.
Carver Corp., The, Norwood, Mass.

★Indicates Advertiser

★Chemical Development Corp., Danvers, Mass.
Chemical & Engineering Associates, Upper Darby, Pa.
Chemical Industries, Unit of E. F. Van Winkle Co., Pasadena, Calif.
Collins, Caldwell & Dague, Inc., Paramount, Calif.
Conneaut Rubber & Plastics Co., Conneaut, Ohio
★Cooke Color & Chemical Co., Hackettstown, N. J.
Coz Chemical Corp., Northbridge, Mass.
★Davies Nitrate Co., Inc., New York 6, N. Y.
★Davis, Joseph, Plastics Co., Kearny, N. J.
Dreyfus, L. A., Co., South Plainfield, N. J.
Eastern Plastic Materials, Slatersville, R. I.
Elton, Ted, N. White Plains, N. Y.
Erie Plastics Co., Erie, Pa.
Essex Plastic Machinery Co., Beverly, Mass.
Farrington Texol Corp., Walpole, Mass.
Fassler, M. J., & Co., Inc., Brooklyn 21, N. Y.
Flexible Products Co., Marietta, Ga.
★Garfield Mfg. Co., Wallington, N. J.
★Gering Products, Inc., Kenilworth, N. J.
Gordon-Lacey Chemical Products, Inc., Maspeth 78, N. Y.
Goren, H. L., Co., Chicago 26, Ill.
★Great American Plastics Co., Fitchburg, Mass.
Hastings Plastics, Inc., Santa Monica, Calif.
★Holland, M., Co., Chicago, Ill.
Houghton Laboratories, Inc., Olean, N. Y.
Industrial Sales Engineers, New York 17, N. Y.
Joclin Mfg. Co., Wallingford, Conn.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
L & P Tool Co., Cincinnati 25, Ohio
Lakeside Plastics Corp., Oshkosh, Wis.
Lami-Plast Products Co., Tampa 3, Fla.
Lavorazione Materie Plastiche S.A.S., Torino, Italy
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass.
Linder, D., Plastics, Inc., Erie, Pa.
Liquid Nitrogen Processing Corp., Chester, Pa.
Magnolia Plastics, Inc., Chamblee, Ga.
Maine Molding Products, Boothbay Harbor, Maine
Marbek, Inc., Brooklyn 22, N. Y.
Maynard Plastics, Inc., Salem, Mass.
Mayon Plastics, Hopkins, Minn.
McCormack Rubber Co., Ridgefield Park, N. J.
Mitchell Rand Mfg. Corp., New York 7, N. Y.
Multiplastics, Wallingford, Conn.
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio
Novelty Bias Binding Co., Plastics Div., Chelsea, Mass.
O'Sullivan Rubber Corp., Winchester, Va.
Pasley's Plastic Products, Inc., Atlanta 18, Ga.
Pelmor Laboratories, Inc., Newtown, Pa.
Plastic Materials, Inc., Hicksville, N. Y.
Plastic Molding Powders, Inc., Brooklyn 23, N. Y.
Plymouth Industrial Products, Inc., Sheboygan, Wis.
Polykote, Inc., Cleveland 3, Ohio
Polymer Chemical Co., Cincinnati 12, Ohio
Polyolefin Compounding Corp., Fort Worth, Tex.
Rand Rubber Co., Brooklyn 16, N. Y.
★Reed Plastics Corp., Worcester 8, Mass.
★Rubber Corp. of America, Hicksville, N. Y.
Schramm Fiberglass Products, Inc., Chicago 18, Ill.
Siebert, R. R., Co., The, Rochester 4, N. Y.
Skeist & Schwarz Labs., Inc., Newark 2, N. J.
Steelcote Mfg. Co., St. Louis 3, Mo.
Success Plastics Corp., Indianapolis 6, Ind.
Usines Gheysen, S.A., Lembecq-Hal, Belgium
★Westchester Plastics, Inc., Mamaroneck, N. Y.
★Windsor, R. H., Ltd., Chessington, England
Yates Co., Erie, Pa.

CONSULTANTS

Able Container Co., Chicago, Ill.
Acme Plastic Products Co., Inc., Doylestown, Pa.
Air Cruisers Div., The Garrett Corp., Belmar, N. J.
Al-Be Industries, Bell Gardens, Calif.
American Agile Corp., Maple Heights, Ohio
American Molded Fiberglass, Paterson, N. J.
Apex Reinforced Plastics Div., White Sewing Machine Corp., Cleveland, Ohio
★Appleton Machine Co., Doven Div., Appleton, Wis.
Applied Plastics Co., Inc., El Segundo, Calif.
Aquador Plastics, Inc., Brooklyn, N. Y.
Argo Plastic Products Co., Inc., Cleveland, Ohio
Arnkurt Associate Engineers, New York, N. Y.
Art Plastics Mfg. Co., Los Angeles, Calif.
Atlantic Plastics, Inc., Stamford, Conn.
Axel Plastics Research Laboratories, Brooklyn, N. Y.
Ayres, Samuel, Jr., Associates, Boston, Mass.
Bahlke, Alfred F., Berkeley Heights, N. J.
Barker-Davis Machine Co., Inc., Leominster, Mass.
Bauer, Dr. George, Keene, N. H.
Ber-Design Associates, Irvington, N. J.
Bergen Mold & Engineering Co., Little Ferry, N. J.
Bernard Plastics Molding Corp., Long Island City, N. Y.
Berni, Alan, & Associates, Inc., New York, N. Y.
Bjorksten Research Laboratories for Industry, Inc., Madison, Wis.
★Blackhawk Molding Co., Inc., Addison, Ill.
Blumenthal, Margaret, New York, N. Y.
Bonwitt, Dr. G. L., New York, N. Y.
Borkland Laboratories, Marion, Ind.
Bricmar Mfg. Corp., New York, N. Y.
Budd, John, Co., Eastford, Conn.
Bullock, H. Leslie, New York, N. Y.
Bureau, Achille G., New York, N. Y.
Byrd Plastics, Inc., Erie, Pa.
Caco, Inc., Pomona, Calif.
★Cadillac Plastic & Chemical Co., Detroit, Mich.
Campro Co., The, Canton, Ohio
Cantor, Robert Lloyd, New Brunswick, N. J.
Carmagnola, Ernest D., Jackson Heights, N. Y.
Chance, W. R. & Associates, Inc., Waldorf, Md.
★Chandler Equipment Engineering Co., Anaheim, Calif.
Chemical & Engineering Associates, Upper Darby, Pa.
Chemtron Fiber Glass Co., El Monte, Calif.
Cherry, Peter, Monroe, Conn.
Cincinnati Testing & Research Laboratories, C. T. L. Inc., Cincinnati, Ohio
Colburn Laboratories, Inc., Chicago, Ill.
Colvin-Friedman Co., Springfield, N. J
★Como Plastics Inc., Columbus, Ind.
Conap, Inc., Olean, N. Y.
Conneaut Rubber & Plastics Co., The, Conneaut, Ohio
Custom Coatings Co., Los Angeles, Calif.
★Danielson Mfg. Co., Danielson, Conn.
Darr, Harold W., Associates, Minneapolis, Minn.
DeBell & Richardson, Inc., Hazardville, Conn.
Desert Sunshine Exposure Tests, Phoenix, Ariz.
Devco Engineering, Inc., Caldwell, N. J.
Du Bois, P. Harry, Co., Montclair, N. J.
Durable Plastics Co., Inc., Seattle, Wash.
Durolastic Co., Kenmore 23, N. Y.
★Egan, Frank W., & Co., Somerville, N. J.
Electro-Auto-Lite Co., Bay City, Mich.
Engineering Associated, Winona, Minn.
Euclid Engineering Co., Inc., Upland, Calif.
Evans-Zeier Plastic Co., Madison, Wis.
Everlite Corp., Seattle, Wash.
Fabrico Mfg. Corp., Chicago, Ill.
Falls Hollow Staybolt Co., Cuyahoga Falls, Ohio
Fawn Plastics Co., Inc., Timonium, Md.
★Fine Organics, Inc., New York, N. Y.
Finn and Fram, Sunland, Calif.
Firmaline Products, Inc., Midland Park, N. J.
Firth, F. G., Los Angeles, Calif.
Fischer, Andrew, Associates, Chicago, Ill.
Frisk, Paul W., Brevard, N. C.
Fukal, Alfred F., Houston, Tex.
★G-W Plastic Engineers, Inc., Bethel, Vt.
Garan Chemical Corp., Gardena, Calif.
Gardner Industrial Foundation, Gardner, Mass.
General Machine & Tool Works Inc., Walled Lake, Mich.
Gershen, Irvin J., Maplewood, N. J.
Greenfield, David S., Bronx, N. Y.
Groppe, Henry, Houston, Tex.
★Guild Electronics, Inc., Dynatherm Div., New York, N. Y.
★H.M.S. Associates, Willow Grove, Pa.
H & R Industries, Nazareth, Pa.
Hale and Kullgren, Akron, Ohio
Halsen Mfg. Co., Philadelphia, Pa.
Hart, William A., & Associates, St. Charles, Ill.
Hermach, George R., Associates, Eugene, Ore.
Hughes Plastics, Inc., St. Joseph, Mich.
Industrial Engineering Service, S. Easton, Mass.
Industrial Sales Engineers, New York, N. Y.
Ions Exchange & Chemical Corp., New York, N. Y.
Isochem Resins Corp., Providence, R. I.
Jamison Plastic Corp., North Bellmore, N. Y.

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Jet Specialties Co. Inc., Los Angeles, Calif.
Jodee Plastics Co., Brooklyn, N. Y.
Joliet Plastic, Inc., Joliet, Ill.
Kabar Mfg. Corp., New York, N. Y.
Kaye Plastics Corp., New Brunswick, N. J.
Keck, Henry, Associates, Pasadena, Calif.
Ketchpel Engineering Corp., W. Englewood, N. J.
King Designers, Detroit, Mich.
Klug Engineering Service, Los Angeles, Calif.
Koller Craft Plastic Producers, Inc., Fenton, Mo.
Kreidl Chemico Physical Co., New York, N. Y.
Kreier, George J., & Son, Philadelphia, Pa.
Lami-Plast Products Co., Tampa, Fla.
La Mode Plastic Co., Inc., New York, N. Y.
Levey, Harold A., Laboratories, New Orleans, La.
Levin, Monte L., New York, N. Y.
Libbert Tool & Die, Fort Worth, Tex.
Liberty Cutting Die Co., New York, N. Y.
Liberty, Gene, New York, N. Y.
Ludascher, William C., Eddington, Pa.
Lukens Laboratories, Inc., Newton, Mass.
Lunn Laminates, Inc., Huntington Station, N. Y.
Madan Plastics, Inc., Cranford, N. J.
Maynard Plastics Co., Salem, Mass.
McCutcheon, George, Los Angeles, Calif.
Mechtronics Co., Philadelphia, Pa.
Merchandise Presentation, N. Y., N. Y.
Mitchell's, L. D., Plastic Studio, Pittsburgh, Pa.
Modular Molding Corp., Burlington, N. J.
Molded Products Inc., Los Angeles, Calif.
Mueller, Ernest, Los Angeles, Calif.
Murdoch Engineering, San Leandro, Calif.
Naken, Wm., Los Angeles, Calif.
National Plastics, Inc., Knoxville, Tenn.
★Newark Die Co., Newark, N. J.
Newton Tool & Mfg. Co., Wenonah, N. J.
New England Engineering & Mfg. Co., Worcester, Mass.
New England Laboratories, Inc., Ipswich, Mass.
New Plastic Corp., Los Angeles, Calif.
Oak Engineering Co., Inc., Gloucester City, N. J .
Paragon Plastic Corp., New York, N. Y.
Pearson-Sutton Corp., Newton, Bucks County, Pa.
Peerless Plastics Co., Milwaukee, Wis.
Pelmor Laboratories, Inc., Newtown, Pa.
Peterson, J. E., Research and Development, Elmhurst, N. Y.
Pioneer Plastics, Dayton, Ohio
Plas-Tech Equipment Corp., Waltham, Mass.
Plastic Model Engineering Co., Van Nuys, Calif.
Plastics, Laminates, & Fabrics, Inc., Chicago, Ill.
Plasticrafters, Inc., Cicero, Ill.
Plastic Service Corp., New York, N. Y.
Plastic Suppliers & Manufacturers, Baton Rouge, La.
Plastic Tooling Aids Laboratory, Bridgeport, Conn.

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Plasticrafts, Inc., Denver, Colo.
Plastics by Chapman, Berkeley, Calif.
Plastics Center of Texas, San Antonio, Texas
Plastics Consultant Service, New York, N. Y.
Plastics-Tool Engineering Co., Hackensack, N. J.
Polymold Plastics, Inc., Chicago, Ill.
★Portage Plastics Co. Inc., Portage, Wis.
Premier Plastics Co., Milwaukee, Wis.
Pribble Plastics Products, Inc., New Haven, Ind.
Printon Corp., New York, N. Y.
Protective Lining Corp., Brooklyn, N. Y.
★Pyro Plastics Corp., Union, N. J.
Radiation Applications, Inc., New York, N. Y.
★Raybestos-Manhattan, Inc., Manheim, Pa.
★Reed Plastics Corp., Worcester, Mass.
Regal Plastic Co., Kansas City, Mo.
Resin Research Laboratories, Inc., Newark, N. J.
Reynolds Plastics, Inc., Walled Lake, Mich.
Rhodes, Philip H., & Associates, Cincinnati, Ohio
★Robbins Plastic Machinery Corp., Elkhart, Ind.
Rosenthal, Alfred A., New York, N. Y.
Ross, Milton, Metals Co., The, Southampton, Pa.
Rothenstein, Guy G., Forest Hills, N. Y.
Scheele, Edwin H., Woodside, N. Y.
Schnur-Appel, Union, N. J.
Schramm Fiberglass Products, Inc., Chicago, Ill.
Screen-O-Printer Mfg. Co., Adams, Mass.
Seder Plastic Corp., Fort Collins, Colo.
Sepanski and Associates, Grand Rapids, Mich.
Shannon, Alexander J., Co., The, New York, N. Y.
Singer, Lawrence H., New York, N. Y.
Skeist & Schwarz Laboratories, Inc., Newark, N. J.
Sorel, Frederick, Prospect Heights, Ill.
★South Florida Test Service, Miami, Fla.
Southwestern Plastics, Inc., Houston, Tex.
Sperzel Co., Minneapolis, Minn.
Springfield Fabricators, Inc., Springfield, N. J.
★Standard Tool Co., Leominster, Mass.
Steckler, R., Laboratories, Cleveland, Ohio
Stringfield, Raymond B., Los Angeles, Calif.
Stromes Systems, Inc., N. Y.
Sun Plastic, Inc., Cuyahoga Falls, Ohio
Superior Materials, Inc., New York, N. Y.
★Superior Plastics Inc., Chicago, Ill.
Sylvania Electric Products Inc., Parts Div., Warren, Pa.
Technical Research Institute, Pasadena, Calif.
Thal, Bernard, Boston, Mass.
★Thierica Studios, Inc., Grand Rapids, Mich.
Thombert, Inc., Newton, Iowa
★Tronomatic Machine Mfg. Corp., New York, N. Y.
U.S. Plastic Products, Metuchen, N. J.
Via Plastics, Inc., Philadelphia, Pa.
Wel-Mar Plastics, Inc., Torrance, Calif.
Welch Plastics & Mfg. Co., Inc., Columbus, Ohio
Wills, John A., & Co., Pasadena, Calif.
★Yardley Plastics Co., Columbus, Ohio
Zapf, Charles & Co., Evanston, Ill.
Zenner, Justin, Chicago, Ill.

DESIGNERS, INDUSTRIAL

Aacon Industries, Inc., Brooklyn, N. Y.
★Akron Preform Mold Co., Cuyahoga Falls, Ohio
Al-Be Industries, Bell Gardens, Calif.
Apex Reinforced Plastics Div., White Sewing Machine Corp., Cleveland, Ohio
Arnkurt Associate Engineers, New York
Art Plastics Mfg. Co., Los Angeles, Calif.
Atlas Plastics, Inc., Little Ferry, N. J.
Ayres, Samuel, Jr., Assoc., Boston, Mass.
Bacon & Weber, Chicago, Ill.
Bahlke, Alfred F., Berkeley Heights, N. J.
Becker & Becker Associates, New York, N. Y.
Beinert, John David, New York, N. Y.
Ber-Design Associates, Irvington, N. J.
Bernard Plastics Molding Corp., Long Island City, N. Y.
Berni, Alan, & Assoc., Inc., New York N. Y.
★Blackhawk Molding Co., Inc., Addison, Ill.
Blumenthal, Margaret, New York, N. Y.
Budd, John Co., Eastford, Conn.
Bureau, Achille G., New York, N. Y.
Campro Co., The, Canton, Ohio
Cantor, Robert Lloyd, New Brunswick, N. J.
Carmagnola, Ernest D., Jackson Heights, N. Y.
Cary Products Co., The, Dallas, Texas
★Chandler Equipment Engineering Co., Anaheim, Calif.
Chapman, Dave, Inc., Chicago, Ill.
Chemtron Fiber Glass Co., El Monte, Calif.
Cherry, Peter, Monroe, Conn.
★Como Plastics Inc., Columbus, Ind.
Couroc of Monterey, Monterey, Calif.
Covey, Laird, Monroe, Conn.
Darr, Harold W., Associates, Minneapolis, Minn.
Davies, Helen & Associates, New York, N. Y.
DeBell & Richardson, Inc., Hazardville, Conn.
Design Dynamics, Inc., Chicago, Ill.
Deskey, Donald, Associates, New York, N. Y.
Doven Machine & Engineering, Inc., Chicago, Ill.
Ehrman, Ernst, New York, N. Y.
Ellies, David, Industrial Design, Inc., Columbus, Ohio
Engineering Associated, Winona, Minn.
Fabrico Mfg. Corp., Chicago, Ill.
Fawn Plastics Co., Inc., Timonium, Md.
Federico, Joseph B., Rochester, N. Y.
Florian, Gordon, Bridgeport, Conn.
Fukal, Alfred F., Houston, Tex.
★G-W Plastic Engineers, Inc., Bethel, Vt.
Gershen, Irvin J., Maplewood, N. J.
Gore, Fred M., Dallas, Tex.
★Goulding Mfg. Co., Saginaw, Mich.
Grover, Frederic S., Associates, Rochester, N. Y.
Gruen, Robert, Associates, New York, N. Y.
Guild Molders, Inc., Elmford, N. Y.
★H.M.S. Associates, Willow Grove, Pa.
Hall, Frances Cushing, Charlotte, N. C.
Halsen Mfg. Co., Philadelphia, Pa.
Harper Landell & Associates, Philadelphia, Pa.
Hart, William A., & Associates, St. Charles, Ill.

Howell, James & Marie, Providence, R. I.
Hughes, Henry, Belmont, Calif.
Hughes Plastics, Inc., St. Joseph, Mich.
Huxtable, L. Garth, New York, N. Y.
Industrial Engineering Service, S. Easton, Mass.
Industrial Plastic Fabricators, Norwood, Mass.
Jacobson, S. I., Mfg. Co., Chicago, Ill.
Karlstad, Andrew C., Sherman Oaks, Calif.
Keck, Henry, Associates, Pasadena, Calif.
Ketchpel Engineering Corp., W. Englewood, N. J.
King Designers, Detroit, Mich.
Koller Craft Plastic Products, Inc., Fenton, Mo.
Kreier Jr., George, Inc., Philadelphia 30, Pa.
La Mode Plastic Co., Inc., New York, N. Y.
Levin, Monte L., New York, N. Y.
Lindsay, John, Denver, Colo.
Lippincott & Margulies, Inc., New York, N. Y.
Madan Plastics, Inc., Cranford, N. J.
McCutcheon, George, Los Angeles, Calif.
★Microcell, Ltd., London, England
Mitchell Plastics, Inc., Owosso, Mich.
Modern Designers, Hialeah, Fla.
Murdoch Engineering, San Leandro, Calif.
Naken, Wm., Los Angeles, Calif.
New Plastic Corp., Los Angeles, Calif.
Norco Plastic Inc., Milwaukee, Wis.
O'Connell, D. C., Associates, New York, N. Y.
Paragon Plastic Corp., New York, N. Y.
Pearson-Sutton Corp., Newton, Bucks County, Pa.
Plastic Model Engineering Co., Van Nuys, Calif.
Plasticrafters, Inc., Cicero, Ill.
Plastics Center of Texas, San Antonio, Tex.
Plastics, Laminates, & Fabrics, Inc., Chicago, Ill.
Polymold Plastics, Inc., Chicago, Ill.
Powell, Jim, Los Angeles, Calif.
Preble, Harry, Cross River, N. Y.
Presco Plastics, Milwaukee, Wis.
Regal Plastic Co., Kansas City, Mo.
Reinhardt Plastics Co., Denver, Col.
Roger's Product Design, Leominster, Mass.
Rosenthal, Alfred A., New York, N. Y.
Rothenstein, Guy G., Forest Hills, N. Y.
Scheele, Edwin H., Woodside, N. Y.
Schnur-Appel, Union, N. J.
Science Service & Supply Co., W. Boylston, Mass.
Sherman, Alan E., & Associates, Clayton (St. Louis), Mo.
Singer, Lawrence H., New York, N. Y.
Somerset Industrial Designs, Inc., Somerville, N. J.
Southwestern Plastics, Inc., Houston, Tex.
Sperzel Co., Minneapolis, Minn.
Staub, David E., Westfield, N. J.
Stensgaard, W. L., and Associates, Inc., Chicago, Ill.
Technical Research Institute, Pasadena, Calif.
Thal, Bernard, Boston, Mass.
Timely Products Co., Des Moines, Iowa
Triana, Rafael, New York, N. Y.
Vavrik, Louis, Rossford, Ohio
Via Plastics, Inc., Philadelphia, Pa.
★Yardley Plastics Co., Columbus, Ohio
Zapf, Charles, & Co., Evanston, Ill.

★Indicates Advertiser

DIE CUTTING PLASTIC SHEET STOCK

A.A.A. Plastic Co., New York 17, N. Y.
A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
A.B.S. Mfg. Co., Inc., New York 11, N. Y.
Aacon Industries, Inc., Brooklyn 24, N. Y.
Able Steel Rule Die Co., New York 12, N. Y.
Accurate Steel Rule Die Mfrs., New York 10, N. Y.
Acme Laminating & Plastics Co., Inc., Detroit, Mich.
Allegheny Plastics, Inc., Coraopolis, Pa.
Atti Engineering Corp., Union City, N. J.
Bedford Products, Inc., Roanoke, Va.
Berkander, George F., Inc., Providence 7, R. I.
★Blank, Arthur & Co., Inc., Boston 15, Mass.
Brandywine Fibre Products Co., Wilmington, Del.
Bricmar Mfg. Corp., New York 13, N. Y.
Brockton Plastics, Inc., Brockton, Mass.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
★Carroll, J. B., Co., Chicago 12, Ill.
Colvin-Friedman Co., Springfield, N. J.
Contour Packaging Co., Philadelphia 27, Pa.
Crook, William A., Co., Inc., Watertown 72, Mass.
Crystal Plastic, Inc., Brooklyn 5, N. Y.
Curry Arts, Scranton 9, Pa.
Custom Merchandise Corp., Brooklyn 1, N. Y.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
★DeWitt Plastics Div., Shoe Form Co., Inc., Auburn, N. Y.
Duplicon Co., Inc., Westboro, Mass.
Electro-Chemical Products, Cleveland 10, Ohio
Electro Plastics Corp., Dallas 7, Texas
★Emeloid Co., Inc., The, Hillside 5, N. J.
Evans-Zeier Plastic Co., Madison 4, Wis.
Fabri-Form Co., The, Byesville, Ohio
Fabri-Kal Corp., Kalamazoo, Mich.
Falge Engineering Corp., Bethesda 14, Md.
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
G & S Label Corp., New York 1, N. Y.
★General American Transportation Corp., Plastics Div., Chicago 90, Ill.
General Machine & Tool Works, Walled Lake, Mich.
Gill, M. C., Corp., S. El Monte, Calif.
Goodren Products Corp., Englewood, N. J.
Harva Co., Inc., The, Schoharie, N. Y.
Hero Mfg. Co., Inc., Middleboro, Mass.
★Hopp Plastics, Div. of the Hopp Press Inc., New York 1, N. Y.
Industrial Engineering Service, South Easton, Mass.
Industrial Sales Engineers, New York 17, N. Y.
Insulating Fabricators of New England, Inc., Watertown 72, Mass.
International Plastic Co., New York 29, N. Y.
Jacobson, S. I., Mfg. Co., Chicago 5, Ill.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
Kerrco Products, Lincoln 7, Neb.
Laminated Sheet Products Corp., Norwood, Mass.
Lansky Die Cutting Corp., Brooklyn 15, N. Y.
Leathertone, Inc., Boston 14, Mass.
Long, Thomas J., Inc., Carle Place, N. Y.
Lustra-Cite Industries, Inc., Brooklyn 11, N. Y.
Madan Plastics, Inc., Cranford, N. J.
Majestic Creations, Inc., Woodside 77, N. Y.
Malco Plastics, Inc., Baltimore 15, Md.
Martin, Fair, Boxes, Inc., Concord, N. C.
Motson, J. Frank, Co., Flourtown, Pa.
New England Die Co. Inc., Taunton, Mass.
North Star Industries, Inc., Hopkins, Minn.
Ormond Mfg. Co., Inc., New York 18, N. Y.
Pam Company, Portland 9, Ore.
Paragon Plastic Corp., New York 12, N. Y.
Pasley's Plastic Products, Inc., Atlanta 18, Ga.
★Perforating Industries, Inc., Roselle Park, N. J.
Perma Seal Plastic Products Co., St. Paul 4, Minn.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastic Parts Corp., Maumee, Ohio
Plastic Service Corp., New York 10, N. Y.
★Plastic Stamping & Molding Corp., Chicago 47, Ill.
Plastic Suppliers and Manufacturers, Baton Rouge, La.
Plastics by Chapman, Richmond, Calif.
Plastics, Inc., St. Paul 5, Minn.
Plastics Industries, Inc., Athens, Tenn.
Polykote, Inc., Cleveland 3, Ohio
★Portage Plastics Co., Portage, Wis.
Premier Plastics Co., Milwaukee 4, Wis.
Printloid, Inc., Long Island City 1, N. Y.
Printon Corp., New York 10, N. Y.
Product Engineering & Development Co., Hopkins, Minn.
Regal Plastic Co., Kansas City 27, Mo.
Reynolds Plastics, Inc., Walled Lake, Mich.
Rome Plastics Specialties, Inc., Worcester 9, Mass.
S-L-M Plastics, Avenel, N. J.
★Sandman, Eli, Co., Worcester 9, Mass.
Santay Corp., Chicago 24, Ill.
Sawaya Mfg. Co., Inc., Trinidad, Colo.
Schjeldahl, G. T., Co., Northfield, Minn.
Shaw-Randall Co., Inc., Pawtucket, R. I.
★Sierra Electric Corp., Gardena, Calif.
★Sillcocks Miller Co., The, Maplewood, N. J.
Southern Plastic Products Co., Riviera Beach, Fla.
Springfield Fabricators, Inc., Springfield, N. J.
Staff Die Cutting Co., New York 10, N. Y.
★Swedlow, Inc., Los Angeles, Calif.
Syracuse Plastic Molders, Syracuse 2, N. Y.
Thomas, Charles W., Inc., Philadelphia 24, Pa.
Tico Plastics, Inc., New York 11, N. Y.
★Transilwrap Co., Chicago 40, Ill.
Ultra Plastics, Inc., Philadelphia 30, Pa.
United Mask & Novelty Co., Inc., Glendale, N. Y.
United Progress, Inc., Albany 5, N. Y.
Vacuum Plastics Corp., Columbus 22, Ohio

Valley-National Corp., The, Milldale, Conn.
Victory Plastics Co., Hudson, Mass.
Virginia Plak Co., New York 16, N. Y.
Westech Engineering, Santa Clara, Calif.
Western Coil & Electrical Co., Racine, Wis.

DIE MAKERS, EXTRUSION

ABA Tool & Die Co., Inc., Manchester, Conn.
Ace Plastic Molding Corp., Long Island City 1, N. Y.
Ace Tool & Mfg. Co., Newark 5, N. J.
★Aetna-Standard Div., Blaw-Knox Co., Akron 9, Ohio
Al-Be Industries, South Gate, Calif.
Anson Tools & Gages, Inc., Erie, Pa.
Astor Tool & Die Co., Long Island City 1, N. Y.
★Auburn Plastics, Inc., Auburn, N. Y.
Barclay Industries, Inc., New York, N. Y.
Beazy's Moldmakers, Peru, Ind.
Blaw-Knox Co., Pittsburgh 22, Pa.
★Chandler Equipment Engineering Co., Anaheim, Calif.
★Egan, Frank W., & Co., Somerville, N. J.
Electro Plastics Corp., Dallas 7, Texas
Essex Plastic Machinery Co., Beverly, Mass.
★Faeco Machine Co., Inc., Paterson, N. J.
Federal Tool Corp., Chicago 45, Ill.
Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, W. Germany
★General American Transportation Corp., Plastics Div., Chicago 90, Ill.
Haveg Industries, Inc., Wilmington 8, Del.
Industrial Engineering Service, South Easton, Mass.
★Johnson Mfg. Co., Inc., Chippewa Falls, Wis.
★Killion Tool & Mfg. Co., Verona, N. J.
★Kingman, E. B., Co., Leominster, Mass.
Kunst, John, Co., The, New York 7, N. Y.
L & P Tool Co., Cincinnati 25, Ohio
Lavorazione Materie Plastiche, S.A.S., Torino, Italy
Libbert Plastics, Inc., Fort Worth 14, Texas
Many, J., & Co., New York 13, N. Y.
★Modern Plastic Machinery Corp., Lodi, N. J.
★National Rubber Machinery Co., Akron 8, Ohio
New England Die Co., Inc., Taunton, Mass.
Oakley Die & Mfg. Co. Inc., The, Cincinnati 9, Ohio
Payne Tool & Engineering Co., The, Springfield, Ohio
Plastic Extruded Products Co., Elizabeth 1, N. J.
Plastic Mold Tool & Die Co., Inc., E. Rutherford, N. J.
Prodel, S.A., Societe De Produits Industriels, Paris 16, France
Pyramid Screen Corp., Brookline 46, Mass.
★Robbins Plastic Machinery Corp., Elkhart, Ind.
★Roehlen Engraving Works, Rochester 5, N. Y.
★Royle, John, & Son, Paterson 3, N. J.
Skyline Industries, Titusville, Pa.
★Sterling Extruder Corp., Linden, N. J.
Stricker-Brunhaber Corp., New York 10, N. Y.
★Superior Plastics, Inc., Chicago 12, Ill.
Sussex Plastic Co., Belleville, N. J.
Thermoplastic Equipment Corp., Div. of Thermoplastic Processes, Inc., Stirling, N. J.
★Thermoplastic Processes, Inc., Stirling, N. J.
Victory Plastics Co., Hudson, Mass.
Western Supplies Co., St. Louis 6, Mo.
★Windsor, R. H., Ltd., Chessington, England
Yates Co., Erie, Pa.

DIE MAKERS, HIGH-FREQUENCY HEAT SEALING

A & S Steel Rule Die Corp., New York 2, N. Y.
Able Steel Rule Die Co., New York 12, N. Y.
Acme Laminating & Plastics Co., Inc., Detroit, Mich.
Allied Engravers, Inc., New York 12, N. Y.
★Callanan, J. A., Co., Chicago 6, Ill.
★Cosmos Electronic Machine Corp., New York 12, N. Y.
★Mayflower Electronic Devices, Inc., Little Ferry, N. J.
★Peterson, A. W., & Sons Die Co., Inc., New York 12, N. Y.
Plastics by Chapman, Richmond, Calif.
Printon Corp., New York 10, N. Y.
Reeve Electronics, Inc., Chicago 6, Ill.
★Superior Plastics, Inc., Chicago 12, Ill.
Victory Plastics Co., Hudson, Mass.
Western Supplies Co., St. Louis 6, Mo.

DIP COATING, PLASTICS

(See Coating)

EMBEDDING

A.A.A. Plastic Co., New York 17, N. Y.
A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
Aacon Industries, Inc., Brooklyn 24, N. Y.
Alda Plastics, Inc., New York 13, N. Y.
All-Tech Industries, Inc., Miami 68, Fla.
Aries Laboratories, Inc., Long Island City, N. Y.
Bacon & Weber, Chicago 22, Ill.
Bentek Co., Brooklyn 16, N. Y.
Biggs, Carl H., Co., Inc., Santa Monica, Calif.
Boonton Molding Co., Boonton, N. J.
Brilhart Plastics Corp., Mineola, N. Y.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Clearfloat, Inc., Attleboro, Mass.
Comet Novelty Co., Adams, Mass.
Conn-Craft Co., Waterbury 5, Conn.
Conroc of Monterey, Monterey, Calif.
Crystal-X Corp., Lenni Mills, Pa.
DeBell Richardson, Inc., Hazardville, Conn.
Distinctive Embedments, Inc., Providence 6, R. I.
★Emeloid Co., Inc., The, Hillside 5, N. J.
Emerson & Cuming, Inc., Canton, Mass.
General Machine & Tool Works, Walled Lake, Mich.
Hanley Plastics Co., St. Louis 17, Mo.
Houghton Laboratories, Inc., Olean, N. Y.
Industrial Sales Engineers, New York 17, N. Y.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass.
Leathertone, Inc., Boston 14, Mass.
Lumar Optical Mfg. Co., Inc., Mount Vernon, N. Y.
Maine Molding Products, Boothbay Harbor, Maine
Metallic Plastics Corp., Long Island City 1, N. Y.
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
Mitchell's, L. D., Plastic Studio, Pittsburgh 12, Pa.
Modular Molding Corp., Burlington, N. J.
Molding Corp. of America, Inc., Providence 3, R. I.
New England Die Co., Inc., Taunton, Mass.
Plastex Laminates, Inc., Hialeah, Fla.
Plastic Laminating Corp., Vauxall, N. J.
Plastic Suppliers and Mfrs., Baton Rouge, La.
Plastics by Chapman, Richmond, Calif.
Plastics by Hoover, Huntington, W. Va.
Plastics Industries, Inc., Athens, Tenn.
Plasti-Skill Co., Corona 68, N. Y.
Polyplastex United, Inc., Union, N. J.
Reynolds Plastics, Inc., Walled Lake, Mich.
Ridge Printing Co., Inc., Ridgefield, N. J.
★Sillcocks Miller Co., The, Maplewood, N. J.
Superior Laminating Co., New York 2, N. Y.
★Superior Plastics, Inc., Chicago 12, Ill.
Technicraft Co., Boston 34, Mass.
Therm-O-Form Plastics Co., Homewood, Ill.
Urrite Plastics Fabricators, Pico Rivera, Calif.
Wasco Products, Inc., Cambridge 38, Mass.
Westech Engineering, Santa Clara, Calif.

EMBOSSING

A. *Flexible Film and Sheeting*
B. *Rigid Plastic Sheets*

A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash. (B)
Aacon Industries, Inc., Brooklyn 24, N. Y. (A, B)
Acme Laminating & Plastics Co., Inc., Detroit, Mich. (B)
Allied Engineering & Production Corp., Alameda, Calif. (A, B)
Barr Corp., The, Richmond Hill, N. Y. (A, B)
Belon Chemical Co., Inc., Cranston 10, R. I. (A, B)
Borkland Mfg. Co., Marion, Ind. (B)
Bostrom Corp., Milwaukee 4, Wis. (A)
Brockton Plastics, Inc., Brockton, Mass. (A, B)
Brutier Product Co., Inc., Secaucus, N. J. (A)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (A)
Canton Containers, Inc., Canton 7, Ohio (A)
★Carroll, J. B., Co., Chicago 12, Ill. (B)
Coating Products, Inc., Englewood, N. J. (A)
Cromwell Paper Co., Chicago 1, Ill. (A)
Crowl, Charles Co., El Monte, Calif. (A, B)
Crystal-X Corp., Lenni Mills, Pa. (A, B)
★Davis, Joseph, Plastics Co., Kearny, N. J. (B)
Defiance Machine & Tool Co., St. Louis 10, Mo. (A, B)
Efka Plastic Corp., Hoboken, N. J. (A)
Electro Plastics Corp., Dallas 7, Texas (A, B)
★Emeloid Co., Inc., The, Hillside 5, N. J. (A, B)

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Fabric Leather Corp., New York 1, N. Y. (A)
Falge Engineering Corp., Bethesda 14, Md. (A, B)
Fassler, M. J., & Co., Inc., Brooklyn 21, N. Y. (A)
Fersons Industries, Inc., New York 1, N. Y. (A)
Flexcon Co., Spencer, Mass. (A, B)
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio (A)
Franklin Fibre-Lamitex Corp., Wilmington 99, Del. (A, B)
General Machine & Tool Works, Walled Lake, Mich. (A, B)
★General Plastics Corp., Marion, Ind. (B)
Gomar Mfg. Co., Inc., Linden, N. J. (A)
Gordon-Lacey Chemical Products, Inc., Maspeth 78, N. Y. (A)
Industrial Sales Engineers, New York 17, N. Y. (B)
Intraplast Mfg. Co., New York 4, N. Y. (A)
Jacobson, S. I., Mfg. Co., Chicago 5, Ill. (A)
Kerrco Products, Lincoln 7, Neb. (B)
Landers Corp., The, Toledo 1, Ohio (A)
Lansky Die Cutting Corp., Brooklyn 15, N. Y. (B)
Lavorazione Materie Plastiche, S.A.S., Torino, Italy (A, B)
Leathertone, Inc., Boston 14, Mass. (A, B)
Lus-Trus Corp., Ypsilanti, Mich. (B)
Madan Plastics, Inc., Cranford, N. J. (A, B)
Maine Molding Products, Boothbay Harbor, Maine (B)
Marbek, Inc., Brooklyn 22, N. Y. (A)
Martin, Fair, Boxes, Inc., Concord, N. C. (A)
Maynard Plastics, Inc., Salem, Mass. (A)
Modern Engraving & Machine Co., Hillside, N. J. (A, B)
O'Sullivan Rubber Corp., Winchester, Va. (A, B)
Paragon Plastic Corp., New York 12, N. Y. (B)
Pearson Industries, Long Island City 1, N. Y. (A, B)
Plastex Laminates, Inc., Hialeah, Fla. (B)
Plastic Laminating Corp., Vauxall, N. J. (B)
Plastic Service Corp., New York 10, N. Y. (A, B)
Polyplastex United, Inc., Union, N. J. (A, B)
Premier Plastics Co., Milwaukee 4, Wis. (B)
Printloid, Inc., Long Island City 1, N. Y. (B)
Printon Corp., New York 10, N. Y. (A, B)
Rich-Tex, Inc., Cedar Grove, N. J. (A, B)
Ridge Printing Co., Inc., Ridgefield, N. J. (A, B)
Roltex Process Corp., Roselle, N. J. (A)
Ross & Roberts, Inc., Stratford, Conn. (A)
Roysons, Inc., Cedar Grove, N. J. (A, B)
★Sillcocks Miller Co., The, Maplewood, N. J. (B)
★Southern Plastics Co., Columbia 1, S. C. (A, B)
Southern Plastic Products Co., Riviera Beach, Fla. (B)
Sun Steel Co., Chicago 36, Ill. (A, B)
Syracuse Plastic Molders, Syracuse 2, N. Y. (A, B)
Therm-O-Form Plastics Co., Homewood, Ill. (A, B)
Tico Plastics, Inc., New York 11, N. Y. (B)
Timely Products Co., Des Moines 15, Iowa (B)
Ultra Plastics, Inc., Philadelphia 30, Pa. (B)
United Mask & Novelty Co., Inc., Glendale, N. Y. (B)
Usines Gheysen, S.A., Lembecq-Hal, Belgium (A, B)
Velveray Corp., New York 1, N. Y. (A)
Wellington Print Works, Inc., Trenton, N. J. (A)
Willson Camera Co., Havertown, Pa. (A, B)
Woodall Industries, Inc., Detroit 34, Mich. (B)

EXPORTERS AND IMPORTERS

A. Machinery
B. Molding Compounds
C. Resins

A & S Steel Rule Die Corp., New York 2, N. Y. (A)
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio (A)
Alpha Chemical & Plastics Corp., Newark 5, N. J. (B)
Amco Plastic Materials, Inc., Brooklyn 31, N. Y. (B, C)
American Pyroxylin Corp., Kearny, N. J. (B, C)
American Vinyl Corp., Maspeth 78, N. Y. (C)
Architectural Plastics Corp., Eugene, Ore. (C)
Baco Co., New York 13, N. Y. (A, B, C)
Bamberger, Claude P., Inc., Ridgefield Park, N. J. (B, C)
Barclay Industries, Inc., New York, N. Y. (A)
Berthelsen Engineering, Joilet, Ill. (A)
★Birbach L. E., Associates, Inc., Boston (Malden) 48, Mass. (A)
Blum, Paul, Co., Buffalo 10, N. Y. (B)
Bricmar Mfg. Corp., New York 13, N. Y. (A)
Buttondex Corp., New York 16, N. Y. (A)
Carver Corp., The, Norwood, Mass. (B)
Chemtron Fiber Glass Co., El Monte, Calif. (B, C)
Danson, Barnett J., & Associates, Ltd., Toronto 12, Ont., Canada. (A)
★Dayton Rubber Co., The, Dayton, Ohio (C)
Erie Plastics Co., Erie, Pa. (B, C)
Erinac Equipment Corp., New York 12, N. Y. (A)
Goren, H. L., Co., Chicago 26, Ill. (B)
★Hochman Plastics Machinery Corp., Newark 2, N. J. (A)
Industrial Plastics, Ltd., London W.1, England (A, B)
International Eastern Co., New York 1, N. Y. (A)
★Interplastics Corp., New York 22, N. Y. (B)
Kenrich Corp., Maspeth 78, N. Y. (C)
★Koppers Co., Inc., Plastics Div., Pittsburgh 19, Pa. (C)
Laminated Fiberglass Corp. of America, New York 5, N. Y. (C)
Leedpak, Inc., New York 1, N. Y. (A)
Linder, D., Plastics, Inc., Erie, Pa. (B)
Many, J., & Co., New York 13, N. Y. (A)
Monkley Corp., Worcester 8, Mass. (A)
★Muehlstein, H., & Co., New York 17, N. Y. (B, C)
Oppenheimer Corp., Buffalo 10, N. Y. (B, C)
Paterson Foundry and Machine Co., The, E. Liverpool, Ohio (A)
Plastic Laminating Corp., Vauxall, N. J. (A)
Plastic Molding Powders, Inc., Brooklyn 23, N. Y. (B)
Polypenco, Inc., Reading, Pa. (B, C)
Poser, J., & Co., New York 1, N. Y. (A, B)
Rayll Plastics Co., Brooklyn 6, N. Y. (C)
Rosenthal, Alfred A., New York 38, N. Y. (A)
Shuman, Philip, & Sons, Buffalo 6, N. Y. (B, C)
Specialty Products Co., Jersey City 2, N. J. (B)
★Union Carbide International Co., Div. of Union Carbide Corp., New York 17, N. Y. (C)
United Sales Service, Los Angeles 35, Calif. (A, B, C)
Western Plastic & Rubber Co., Richmond, Calif. (B, C)
★Woloch, George, Co., Inc., New York 11, N. Y. (C)

FABRICATORS

A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
A.B.S. Mfg. Co., Inc., New York 11, N. Y.
Aacon Industries, Inc., Brooklyn 24, N. Y.
★Ace Plastic Co., Jamaica 35, N. Y.
Airconductors, Gardena, Calif.
Alda Plastics Inc., New York 13, N. Y.
Allied Engineering & Production Corp., Alameda, Calif.
Allied Plasti-Lite Enterprises, Inc., St. Louis 4, Mo.
Allied Plastics Supply Corp., New York 38, N. Y.
All-Tech Industries, Inc., Miami 68, Fla.
Alvimar Mfg. Co., Inc., New York 35, N. Y.
American Agile Corp., Bedford, Ohio
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J.
Ameriplastic Co., The, Flint 7, Mich.
Apex Reinforced Plastics Div., White Sewing Machine Corp., Cleveland 6, Ohio
Argo Plastic Products Co., Cleveland 13, Ohio
Aristocrat Plastics, Inc., Newark 3, N. J.
Arrem Plastics, Inc., Chicago 12, Ill.
Atkins & Merrill, Inc., Reinforced Plastics Div., Marlboro, Mass.
Atlantic Mfg. Co., Philadelphia 22, Pa.
Atlas Mineral Products Co., Mertztown, Pa.
Atti Engineering Corp., Union City, N. J.
★Auburn Plastic Engineering, Chicago 9, Ill.
Bacon & Weber, Chicago 22, Ill.
Bel-Art Products, Pequannouk, N. J.
Belon Chemical Co., Inc., Cranston 10, R. I.
Bentek Co., Brooklyn 16, N. Y.
Berkander, George F., Inc., Providence 7, R. I.
Berthelsen Engineering, Joliet, Ill.
Berton Plastics, Inc., New York 3, N. Y.
★Blank, Arthur & Co., Inc., Boston 15, Mass.
Bolling Industries, Inc., Scranton 5, Pa.
Borkland Mfg. Co., Marion, Ind.
Brandywine Fibre Products Co., Wilmington, Del.
Bricmar Mfg. Corp., New York 13, N. Y.
Brilhart Plastics Corp., Mineola, N. Y.
Brockton Plastics, Inc., Brockton, Mass.

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Brooklyn Plastic Co., Inc., Brooklyn 1, N. Y.
★Brunswick-Balke-Collender Co., Defense Products Div., Muskegon, Mich.
C.T.L., Inc., Cincinnati 15, Ohio
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Canton Containers, Inc., Canton 7, Ohio
★Capitol Plastics Co., Lansing, Mich.
★Carroll, J. B., Co., Chicago 12, Ill.
★Cast Optics Corp., Hackensack, N. J.
Chatelain Plastics, Findlay, Ohio
Chemtron Fiber Glass Co., El Monte, Calif.
★Colonial Kolonite Co., Chicago 47, Ill.
Colvin-Friedman Co., Springfield, N. J.
Comet Novelty Co., Adams, Mass.
Conn-Craft Co., Waterbury 5, Conn.
Consolidated Plastics & Mfg. Co., Chicago 10, Ill.
Crook, William A., Co., Inc., Watertown 72, Mass.
Crystal Plastic, Inc., Brooklyn 5, N. Y.
Crystal-X Corp., Lenni Mills, Pa.
Curbell, Inc., Buffalo 7, N. Y.
Curry Arts, Scranton 9, Pa.
★D & R Plastic Welders, Inc., Hazardville, Conn.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
★DeWitt Plastics Div., Shoe Form Co., Inc., Auburn, N. Y.
Disogrin Industries, Inc., Mt. Vernon, N. Y.
Dixie Plastics Mfg. Co., New Orleans, La.
Duplicon Co., Inc., Westboro, Mass.
Durable Plastics Co., Inc., Seattle 4, Wash.
Dura Plastics of New York, Inc., New York 16, N. Y.
Du Verre, Inc., Arcade, N. Y.
Electro-Chemical Products, Cleveland 10, Ohio
Electro Plastics Corp., Dallas 7, Texas
Electro Plastic Fabrics, Inc., Pulaski, Va.
★Emeloid Co., Inc., The, Hillside 5, N. J.
Emerson Plastics Corp., Bronx 61, N. Y.
★Engineered Plastics, Inc., Gibsonville, N. C.
Evans-Zeier Plastic Co., Madison 4, Wis.
Eveready Plastics, Atlanta 8, Ga.
Fabri-Form Co., The, Byesville, Ohio
Fabri-Kal Corp., Kalamazoo, Mich.
Falcon, Inc., Santa Monica, Calif.
Falge Engineering Corp., Bethesda 14, Md.
Falk Glass & Plastic Co., Inc., Long Island City 3, N. Y.
Fassler, M. J., & Co., Inc., Brooklyn 21, N. Y.
Fawn Plastics Co., Inc., Timonium, Md.
Federal Tool Corp., Chicago 45, Ill.
Fiber Glass Plastic, Inc., Miami 47, Fla.
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
Fried Novelties, Brooklyn 19, N. Y.
Gemloid Corp., Long Island City, N. Y.
General Foam Corp., New York 31, N. Y.
General Machine & Tool Works, Walled Lake, Mich.
★General Plastics Corp., Marion, Ind.
General Plastics Mfg. Co., Tacoma 2, Wash.
Gladwin Plastics, Inc., Atlanta 3, Ga.
★Glo-Brite Foam Plastic Products, Chicago 45, Ill.

Gotham Plastics Corp., Bronx 51, N. Y.
Greene, Ray, & Co., Toledo 9, Ohio
Halogen Insulator & Seal Corp., Franklin Park, Ill.
Hampden Mfg. Co., Inc., Three Rivers, Mass.
Har-E-Dan Engravers, Brooklyn, N. Y.
Harva Co., Inc., The, Schoharie, N. Y.
Haveg Industries, Inc., Wilmington 8, Del.
Heil Process Equipment Corp., Cleveland 11, Ohio
Hermes Plastics, Inc., New York 14, N. Y.
Hero Mfg. Co., Inc., Middleboro, Mass.
High Strength Plastics Corp., Chicago 7, Ill.
★Hopp Plastics, Div. of the Hopp Press Inc., New York 1, N. Y.
Houghton Laboratories, Inc., Olean, N. Y.
Imperial Industries, Inc., Wayne, Mich.
Industrial Plastic Fabricators, Norwood, Mass.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Industrial Sales Engineers, New York 17, N. Y.
Industrial Vinyls, Inc., Miami 42, Fla.
Insulating Fabricators Co., Inc., E. Rutherford, N. J.
Insulating Fabricators of New England, Inc., Watertown 72, Mass.
International Plastic Co., New York 29, N. Y.
I-V Die Mold Co., Peoria, Ill.
Jacobson, S. I., Mfg. Co., Chicago 5, Ill.
Jet Specialties Co., Inc., Los Angeles 63, Calif.
Joclin Mfg. Co., Wallingford, Conn.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
Just Plastics, Inc., New York 34, N. Y.
Kingsbacher Murphy Co., Los Angeles 45, Calif.
Klise Mfg. Co., Grand Rapids 2, Mich.
Klisey Engineering Co., Los Angeles 23, Calif.
Laminated Sheet Products Corp., Norwood, Mass.
Lansky Die Cutting Corp., Brooklyn 15, N. Y.
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass.
Leon Chemical Industries, Inc., Warren, Mich.
Leon Machine & Engineering Co., Riverside, N. J.
Lewis, G. B., Co., Watertown, Wis.
Lone Star Plastics Co., Inc., Fort Worth, Texas
Long, Thomas J., Inc., Carle Place, N. Y.
Lumar Opical Mfg. Co., Inc., Mt. Vernon, N. Y.
Lustra-Cite Industries, Inc., Brooklyn 11, N. Y.
Lus-Trus Corp., Ypsilanti, Mich.
Madan Plastics, Inc., Cranford, N. J.
Maine Molding Products, Boothbay Harbor, Maine
Maynard Plastics, Inc., Salem, Mass.
Mechanical Engraving Co., Inc., New York 68, N. Y.
Merchandise Presentation, Inc., New York 35, N. Y.
Mercury Plastics Corp., Chicopee, Mass.
Microcell, Ltd., London W.C. 2, England
Mitchell's, L. D., Plastic Studio, Pittsburgh 12, Pa.
Modern Plastics, Miami 42, Fla.
Modular Molding Corp., Burlington, N. J.
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio
★Mycalex Corp. of America, Clifton, N. J.

Nalge Co., Inc., The, Rochester 2, N. Y.
★New England Laminates Co., Inc., Stamford, Conn.
New England Tape Co., Hudson, Mass.
Nichols Products Co., Inc., Moorestown, N. J.
Niles Corp., South Bend 17, Ind.
Novelty Bias Binding Co., Plastics Div., Chelsea, Mass.
Omaha Plastics Co., Omaha 8, Neb.
Ormond Mfg. Co., Inc., New York 18, N. Y.
Orna Plastics Co., Los Angeles 34, Calif.
O'Sullivan Rubber Corp., Winchester, Va.
Palisades Plastics Co., Inc., Englewood, N. J.
Pam Company, Portland 9, Ore.
Paragon Plastic Corp., New York 12, N. Y.
Payne Tool & Engineering Co., The, Springfield, Ohio
Pearson-Sutton Corp., Bucks County, Pa.
Pierson Plastic Mfg. Co., Jennings 21, Mo.
Pine-Wood Plastic Co., Inc., Cambridge 42, Mass.
Pitman Plastic Products, Inc., Pitman, N. J.
Plast-Ad Mfg. Co., South Bend, Ind.
Plastic Age Sales, Inc., Saugus, Calif.
Plastic Artisans, Inc., Port Chester, N. Y.
Plastic Center, Rocheser 4, N. Y.
Plastic Corp. of Chicago, Lyons, Ill.
Plastic-Craft Products Corp., W. Nyack, N. Y.
Plastic Engineering Co., Pawtucket, R. I.
Plastic Engineering Co. of Tulsa, Tulsa, Okla.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastic Industrial Products, Div. of Carlon Products Corp., Somerville, 44, Mass.
Plastic Parts Corp., Maumee, Ohio
Plastic Process Co., Div. of Monadnock Mills, Los Angeles 45, Calif.
Plastic Rotocast Co., Chicago 5, Ill.
★Plastic Stamping & Molding Corp., Chicago 47, Ill.
Plastic Suppliers and Manufacturers, Baton Rouge, La.
Plasticles Corp., Detroit 27, Mich.
Plastics by Chapman, Richmond, Calif.
Plastics by Hoover, Huntington, W. Va.
Plastics Center of Texas, San Antonio 4, Texas
Plastics, Inc., St. Paul 5, Minn.
Plastics Industries, Inc., Athens, Tenn.
Plasti-Line, Inc., Knoxville 18, Tenn.
Plastimayd Corp., Portland 14, Ore.
Plasti-Skill Co., Corona 68, N. Y.
Plastofilm, Inc., Wheaton, Ill.
Polo Plastics, Co., Milwaukee 12, Wis.
★Polygon Plastic Co., Walkerton, Ind.
Polymer Corp. of Pa., Reading, Pa.
Polypenco, Inc., Reading, Pa.
★Possis Machine Corp., Minneapolis 3, Minn.
Post Electric Co., Inc., Andover, N. J.
Premier Plastic Mfg. Co., Minneapolis 26, Minn.
Premier Plastics Co., Milwaukee 4, Wis.
Printloid, Inc., Long Island City 1, N. Y.
Printon Corp., New York 10, N. Y.
Protective Lining Corp., Brooklyn 31, N. Y.
Raven Industries, Inc., Sioux Falls, S. D.
Regal Plastic Co., Kansas City 27, Mo.
Reinhardt, J. A., Co., Mountain Home, Pa.

★Indicates Advertiser

Resistoflex Corp., Roseland, N. J.
Reynolds Plastics, Inc., Walled Lake, Mich.
Rome Plastic Specialties, Inc., Worcester 9, Mass.
Ryerson, Jos. T., & Son, Inc., Chicago, Ill.
S-L-M Plastics, Avenel, N. J.
Scheidl Mfg. Co., Copiague, N. Y.
Schramm Fiberglass Products, Inc., Chicago 18, Ill.
Schjeldahl, G. T., Co., Northfield, Minn.
Schori Prcoess Corp., Long Island City 1, N. Y.
Sealy Plastics Corp., Rockville, Conn.
Sharpe Plastics, Inc., Sudbury, Mass.
Shaw-Randall Co., Inc., Pawtucket, R. I.
★Sierra Electric Corp., Gardena, Calif.
Sierracin Corp., The, Burbank, Calif.
Silicone Insulation, Inc., Bronx 61, N. Y.
★Sillcocks Miller Co., The, Maplewood, N. J.
Singleton & Mack, Inc., Akron 13, Ohio
Solar Plastic Products Co., Brooklyn 5, N. Y.
South Salem Studios, South Salem, N. Y.
Southeastern Sales Corp., St. Petersburg 13, Fla.
Souhwestern Plastics, Inc., Houston 36, Texas
Spartan Products Co., Los Angeles 63, Calif.
Springfield Fabricators, Inc., Springfield, N. J.
Stensgaard, W. L., & Associates, Inc., Chicago 7, Ill.
Stricker-Brunhaber Corp., New York 10, N. Y.
Stricker, Carl, Mechanical Developer, Bloomfield, N. J.
Superior Laminating Co., New York 2, N. Y.
★Swedlow, Inc., Los Angeles, Calif.
Syracuse Plastic Molders, Syracuse 2, N. Y.
Technicraft Co., Boston 34, Mass.
T. O. Plastics, Inc., Minneapolis, Minn.
Tewes Plastics Corp., Waukesha, Wis.
Thombert, Inc., Newton, Iowa
Thompson, H. I., Fiber Glass, Los Angeles 7, Calif.
Tiger Plastics Corp., Brooklyn 22, N. Y.
Transplastics Fabricating Co., Boston 15, Mass.
Ultra Plastics, Inc., Philadelphia 30, Pa.
★United States Gasket Co., Plastics Div. of The Garlock Packing Co., Camden, N. J.
Universal Unlimited, Inc., Glen Cove, N. Y.
Urrite Plastics Fabricators, Pico Rivers, Calif.
Vacuum Plastics Corp., Columbus 22, Ohio
Valley-National Corp., The, Milldale, Conn.
Virginia Plak Co., New York 16, N. Y.
Wachter Plastic Co., Sacramento 14, Calif.
Wama Co., The, Baltimore 2, Md.
Wasco Products, Inc., Cambridge 38, Mass.
Westech Engineering, Santa Clara, Calif.
Western Plastic, Inc., Spokane 3, Wash.
Woodall Industries, Inc., Detroit 34, Mich.
Wyatt's Plastics, Inc., Houston 1, Texas
★Yardley Plastics Co., Columbus 15, Ohio
Young Development Div., Explosives Dept., Hercules Powder Co., Rocky Hill, N. J.

FABRICATORS, EXPANDED PLASTICS

A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
Aacon Industries, Inc., Brooklyn 24, N. Y.
Bacon & Weber, Chicago 22, Ill.
Brilhart Plastics Corp., Mineola, N. Y.
Brockton Plastics, Inc., Brockton, Mass.
Canton Containers, Inc., Canton 7, Ohio
Chemtron Fiber Glass Co., El Monte, Calif.
★Colonial Kolonite Co., Chicago 47, Ill.
Crystal Plastic, Inc., Brooklyn 5, N. Y.
Crystal-X Corp., Lenni Mills, Pa.
Curbell, Inc., Buffalo 7, N. Y.
★Dayton Rubber Co., The, Dayton, Ohio
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
Dielectric Materials Co., Chicago 40, Ill.
Fabri-Form Co., The, Byersville, Ohio
Fabri-Kal Corp., Kalamazoo, Mich.
Falcon, Inc., Santa Monica, Calif.
Fawn Plastics Co., Inc., Timonium, Md.
General Foam Products, Vernon, Calif.
General Machine & Tool Works, Walled Lake, Mich.
Gilman Brothers Co., The, Gilman, Conn.
★Glo-Brite Foam Plastic Products, Chicago 45, Ill.
Hastings Plastics, Inc., Santa Monica, Calif.
Hermes Plastics, Inc., New York 14, N. Y.
Jodee Plastics, Inc., Brooklyn 8, N. Y.
Kimball Manufacturing Corp., San Rafael, Calif.
Laminated Sheet Products Corp., Norwood, Mass.
Liquid Nitrogen Processing Corp., Chester, Pa.
Liss Products, Inc., Grasmore, N. H.
Lone Star Plastics Co., Inc., Fort Worth, Texas
Lustra-Cite Industries, Inc., Brooklyn 11, N. Y.
Madan Plastics, Inc., Cranford, N. J.
Microcell, Ltd., London W.C. 2, England
★Mitchell Specialty Div., Industrial Enterprises, Inc., Philadelphia 36, Pa.
Modular Molding Corp., Burlington, N. J.
★Nopco Chemical Co., N. Arlington, N. J.
North Star Industries, Inc., Hopkins, Minn.
Paragon Plastic Corp., New York 12, N. Y.
Pitman Plastic Products, Inc., Pitman, N. J.
Plastic Age Sales, Inc., Saugus, Calif.
Plastic Engineering Co. of Tulsa, Tulsa, Okla.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastic Model Engineering, Van Nuys, Calif.
Plastic Parts Corp., Maumee, Ohio
Plastics by Chapman, Richmond, Calif.
Plastics Industries, Inc., Athens, Tenn.
Plastomer Corp., Detroit 4, Mich.
Polykote, Inc., Cleveland 3, Ohio
Printon Corp., New York 10, N. Y.
Southwestern Plastics, Inc., Houston 36, Texas
Standard Plastics, Inc., Fogelsville, Pa.
Stensgaard, W. L., & Associates, Inc., Chicago 7, Ill.
Stricker-Brunhaber Corp., New York 10, N. Y.
T. O. Plastics, Inc., Minneapolis, Minn.
Woodall Industries, Inc., Detroit 34, Mich.

FLAME SPRAYING, PLASTICS

Allied Engineering & Production Corp., Alameda, Calif.
American Agile Corp., Bedford, Ohio
Crystal-X Corp., Lenni Mills, Pa.
Fiore, William M., Inc., Brooklyn 32, N. Y.
Plastic Suppliers and Manufacturers, Baton Rouge, La.
Schori Process Corp., Long Island City 1, N. Y.

HEAT SEALING PLASTIC FILM AND SHEET

A. Contact, Impulse
B. Electronic

A & S Steel Rule Die Corp., New York 2, N. Y. (B)
A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash. (B)
Able Steel Rule Die Co., New York 12, N. Y. (B)
Acme Laminating & Plastics Co., Inc., Detroit, Mich. (B)
Alvimar Mfg. Co., Inc., New York 35, N. Y.
Ameriplastic Co., The, Flint 7, Mich. (B)
Anders Corp., Paterson 3, N. J. (B)
Aquador Plastics, Inc., Brooklyn 32, N. Y. (A, B)
Argo Plastic Products Co., Cleveland 13, Ohio (A)
Artmor Plastics Corp., Cumberland, Md. (B)
Art Plastics Mfg. Co., Los Angeles 21, Calif. (B)
Austin Industries, Inc., Marlboro, Mass. (A)
Barr Corp., The, Richmond Hill, N. Y. (B)
Bedford Products, Inc., Roanoke, Va. (B)
Borkland Manufacturing Co., Marion, Ind. (B)
Brewster Enterprises, Inc., Rochester 9, N. Y. (A)
Brockton Plastics, Inc., Brockton, Mass. (B)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (B)
Canton Containers, Inc., Canton 7, Ohio (A, B)
Carbert Mfg. Co., Inc., Cambridge 39, Mass. (A, B)
Chicago Plastic Products Co., Inc., Chicago 10, Ill. (B)
Colvin-Friedman Co., Springfield, N. J. (A, B)
Contour Packaging Co., Philadelphia 27, Pa. (A, B)
★Cosom Engineering Corp., Minneapolis 16, Minn. (B)

★Indicates Advertiser

Cox Plastics Corp., Buffalo 20, N. Y. (B)
Crystal-X Corp., Lenni Mills, Pa. (A, B)
★DeWitt Plastics Div., Shoe Form Co., Inc., Auburn, N. Y. (B)
Dumais, Joseph F., Co., Fall River, Mass. (B)
Electronic Wave Products, Inc., New York, N. Y. (B)
Electro Plastic Fabrics, Inc., Pulaski, Va. (B)
Electro Plastics Corp., Dallas 7, Texas (A, B)
Fabrico Mfg. Corp., Chicago 22, Ill. (B)
Fassler, M. J., & Co., Inc., Brooklyn 21, N. Y. (A, B)
★Ideal Plastics, Div. of Ideal Toy Corp., Hollis 23, N. Y.
Industrial Sales Engineers, New York 17, N. Y. (B)
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn. (B)
Industrial Transparent Products Corp., Freeport, N. Y. (B)
International Plastic Co., New York 29, N. Y. (B)
Jacobson, S. I., Mfg. Co., Chicago 5, Ill. (B)
Kingsbacher Murphy Co., Los Angeles 45, Calif. (B)
Madan Plastics, Inc., Cranford, N. J. (A)
Mankato Paper Box Co., Mankato, Minn. (A, B)
Marbek, Inc., Brooklyn 22, N. Y. (B)
★Mayflower Electronic Devices, Inc., Little Ferry, N. J. (A, B)
Maynard Plastics, Inc., Salem, Mass. (A, B)
Mercury Heat Sealing Equipment Co., Philadelphia 33, Pa. (A)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (A)
New England Tape Co., Hudson, Mass. (B)
Omaha Plastics Co., Omaha 8, Neb. (B)
Packaging Industries, Ltd., Inc., Montclair, N. J. (A)
Plastic Artisans, Inc., Port Chester, N. Y. (B)
Plastic Service Corp., New York 10, N. Y. (B)
Plastics Center of Texas, San Antonio 4, Texas (B)
Plastics by Chapman, Richmond, Calif. (B)
Plastics Industries, Inc., Athens, Tenn. (A, B)
Plastimayd Corp., Portland 14, Ore. (B)
Premier Plastics Co., Milwaukee 4, Wis. (B)
Price Bros. Plastics Corp., Worcester 8, Mass. (B)
Printon Corp., New York 10, N. Y. (A, B)
Protective Lining Corp., Brooklyn 31, N. Y. (A, B)
Raven Industries, Inc., Sioux Falls, S. D. (A)
Reliance Plastic & Chemical Corp., Paterson 26, N. J. (A)
Reynolds Plastics, Inc., Walled Lake, Mich. (A, B)
Ridge Printing Co., Inc., Ridgefield, N. J. (A)
Singleton & Mack, Inc., Akron 13, Ohio (B)
Southern Plastic Products Co., Riviera Beach, Fla. (A)
Spartan Products Co., Los Angeles 63, Calif. (A, B)
Springfield Fabricators, Inc., Springfield, N. J. (A, B)
Syracuse Plastic Molders, Syracuse 2, N. Y. (A, B)
Tewes Plastics Corp., Wankesha, Wis. (B)
Teitelbaum, N., Sons., Inc., New York 51, N. Y. (A)
Things, Inc., Denver 3, Colo. (A, B)
Thomas, Charles W., Inc., Philadelphia 24, Pa. (B)
Victory Plastics Co., Hudson, Mass. (A, B)
Waltco Products, Inc., Chicago 9, Ill. (B)
Woodall Industries, Inc., Detroit 34, Mich. (A)
Wright Sales Co., Newark 5, N. J. (A, B)

HEAT TREATING OF POLYETHYLENE FOR PRINTING

Art Decorating Co., North Bergen, N. J.
Canton Containers, Inc., Canton 7, Ohio
Essex Plastic Machinery Co., Beverly, Mass.
Kreidl Chemico Physical Co., The, New York 21, N. Y.
Maynard Plastics, Inc., Salem, Mass.
Multicraft, Inc., Hillside, Ill.
Novelty Bias Binding Co., Plastics Div., Chelsea, Mass.
Permanent Label Corp., Bloomfield, N. J.
Plastic Art Metallizing Corp., Brooklyn 22, N. Y.
Sperzel Co., Minneapolis 8, Minn.
Tri-State Plastic Molding Co., Henderson, Ky.
Vantine, Inc., Flushing 54, N. Y.

HOBBING

ABA Tool & Die Co., Inc., Manchester, Conn.
Ace Tool & Manufacturing Co., Newark 5, N. J.
Aetna Plastic Die Corp., Chicago 48, Illinois.
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
Allied Engravers, Inc., New York 12, N. Y.
Astor Tool & Die Co., Long Island City 1, N. Y.
★Auburn Plastics, Inc., Auburn, N. Y.
Brilhart Plastics Corp., Mineola, N. Y.
Buttondex Corp., New York 16, N. Y.
★Clifton Hydraulic Press Co., Clifton, N. J.
Daniels-Kummer Engraving Co., Addison, Ill.
E-W Mold & Tool Co., Inc., Indianapolis 6, Ind.
Euclid Engineering Co., Upland, Calif.
Gemloid Corp., Long Island City, N. Y.
General Machine & Tool Works, Walled Lake, Mich.
Helmuth Tool & Die Co., Linden, N. J.
★Hob-Masters, Inc., Lyons, Ill.
Industrial Engineering Service, South Easton, Mass.
Laminated Sheet Products Corp., Norwood, Mass.
Libbert Plastics, Inc., Fort Worth 14, Texas
★Liberty Tool & Machine Co., Irvington 11, N. J.
★Midland Die & Engraving Co., Franklin Park, Ill.
Modern Tool & Die Co., Inc., Leominster, Mass.
Moldcraft, Inc., Baltimore 11, Md.
★Mold Duplicating Co., Kenilworth, N. J.
★Newark Die Co., Newark 2, N. J.
★Newark Die, Hobbing & Casting Co., Newark 2, N. J.
New England Die Co., Inc., Taunton, Mass.
Palfy Die & Mold Co., The, Cleveland 29, Ohio
Payne Tool & Engineering Co., The, Springfield, Ohio
Plastic Mold Tool & Die Co., Inc., E. Rutherford, N. J.
Primas Moldmakers, Inc., Buffalo 11, N. Y.
Reinhold-Geiger Plastics, Inc., Los Angeles 3, Calif.
Seder Plastic Corp., Ft. Collins, Ohio
★Sierra Electric Corp., Gardena, Calif.
Sossner Steel Stamps, Inc., New York 13, N. Y.
★Standard Tool Co., Leominster, Mass.
Stricker-Brunhaber Corp., New York 10, N. Y.
★Superior Plastics, Inc., Chicago 12, Ill.
★Waterbury Companies, Inc., Waterbury, Conn.

METALLIZING

A. Flexible Plastic Film
B. Rigid Plastic Sheets
C. Molded Plastic Poducts (Closures, Novelties, etc.)

Aacon Industries, Inc., Brooklyn 24, N. Y. (A, B, C)
Adams Plastic Products, Cincinnati 14, Ohio (C)
All Purpose Roll Leaf Corp., Paramus, N. J. (A)
American Metalizing Corp., New York 54, N. Y. (C)
★Amos Molded Plastics Div., Amos-Thompson Corp., Edinburg, Ind. (C)
Brutier Product Co., Inc., Secaucus, N. J. (A)
Coating Products, Inc., Englewood, N. J. (A)
Dorrie Process Co., Inc., Brooklyn 22, N. Y. (A)
Electric Auto-Lite Co., The, Toledo 1, Ohio (C)
Electrochemical Industries, Inc., Worcester 3, Mass. (C)
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio (A)
Franklin Fibre-Lamitex Corp., Wilmington 99, Del. (A, B, C)
Futura, Inc., Chicago 8, Ill. (C)
★General American Transportation Corp., Plastics Div., Chicago 90, Ill. (C)
General Machine & Tool Works, Walled Lake, Mich. (A, B, C)
Gits, J. P., Molding Corp., Chicago 44, Ill. (C)
Gomar Mfg. Co., Inc., Linden, N. J. (A)
Hastings & Co., Inc., Philadelphia 3, Pa. (A, B)
Hy-Sil Mfg. Co., Revere, Mass. (A, B)
★Ideal Plastics, Div. of Ideal Toy Corp., Hollis 23, N. Y. (C)
Industrial Sales Engineers, New York 17, N. Y. (A, B, C)
International Plastic Co., New York 29, N. Y. (C)
Jayron Corp., Leominster, Mass. (C)
Lamart Corp., Clifton, N. J. (A)
Marbek, Inc., Brooklyn 22, N. Y. (A)
Metallic Plastics Corp., Long Island City 1, N. Y. (A, B)
Midland Coatings, Inc., Minneapolis 13, Minn. (C)

★Indicates Advertiser

Mitchell Plastics, Inc., Owosso, Mich.
Mueller, Ernest, Los Angeles 36, Calif. (A, B, C)
National Vacuum Platers, Inc., Philadelphia 25, Pa. (C) (C)
Norco Plastic, Inc., Milwaukee, Wis. (C)
Nosco Plastics, Inc., Box 269, Erie, Pa. (C)
Owens-Illinois Glass Co., Toledo 1, Ohio (C)
Parco Co., Newark 5, N. J. (C)
Pearson Industries, Long Island City 1, N. Y. (B)
Planet Plating Co., Inc., Brooklyn 22, N. Y. (C)
Plastic Art Metallizing Corp., Brooklyn 22, N. Y. (C)
Plastic Engineering Co., Pawtucket, R. I. (C)
Plastic Inlays, Inc., Summit, N. J. (B, C)
Plastiplate Co., Inc., South River, N. J. (C)
Platecraft, Inc., Los Angeles 46, Calif. (C)
★Premier Vacuum Process Corp., Maspeth 78, N. Y. (B, C)
Printon Corp., New York 10, N. Y. (A, B)
Prolon Plastics, Florence, Mass. (C)
Santay Corp., Chicago 24, Ill. (C)
★Sinko Mfg. & Tool Co., Chicago 31, Ill. (C)
Specialized Plating Co., Los Angeles 64, Calif. (C)
Sprague-Martin Vacuum Plating Co., Inc., Bayonne, N. J. (A, B, C)
★Superior Plastics, Inc., Chicago 12, Ill. (C)
★Thierica Studio, Inc., Grand Rapids 5, Mich. (C)
Trivac Co., Los Angeles 25, Calif. (C)
Ultra Electroforming & Mfg., Pitman 7, N. J. (C)
Vac-Art, Inc., Bay City, Mich. (B, C)
Vacuum Plate Corp., Culver City, Calif. (C)
★Waterbury Companies, Inc., Waterbury, Conn. (C)
Welch Plastics & Mfg. Co., Inc., Columbus 8, Ohio (C)
Wellington Print Works, Inc., Trenton, N. J. (A)
Wolverine Plastics, Inc., Milan, Mich. (C)

MODEL MAKING SPECIALISTS

A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
Aacon Industries, Inc., Brooklyn 24, N. Y.
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio
Alda Plastics Inc., New York 13, N. Y.
Allied Engineering & Production Corp., Alameda, Calif.
Anson Tools & Gages, Inc., Erie, Pa.
Argo Plastic Products Co., Cleveland 13, Ohio
Arnkurt Associate Engineers, New York 1, N. Y.
Astor Tool & Die Co., Long Island City 1, N. Y.
Atkins & Merrill, Inc., Reinforced Plastics Div., Marlboro, Mass.
Atlantic Mfg. Co., Philadelphia 22, Pa.
Atlas Plastics, Inc., Little Ferry, N. J.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Bacon & Weber, Chicago 22, Ill.
Barradas, George, Glenville, Conn.
Bentek Co., Brooklyn 16, N. Y.
Bergen Mold & Engineering, Little Ferry, N. J.
Bernard Plastics Molding Corp., Long Island City 1, N. Y.
Berton Plastics, Inc., New York 3, N. Y.
★Blackhawk Molding Co., Inc., Addison, Ill.
Bricmar Mfg. Corp., New York 13, N. Y.
Brilhart Plastics Corp., Mineola, N. Y.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
★Capitol Plastics Co., Lansing, Mich.
★Carroll, J. B., Co., Chicago 12, Ill.
Chaney Plastic Molding Co., Denver 16, Colo.
Chemtron Fiber Glass Co., El Monte, Calif.
Classic Studio, New York 16, N. Y.
Clearfloat, Inc., Attleboro, Mass.
Columbia Basin Plastics Co., Portland 1, Ore.
Conn-Craft Co., Waterbury 5, Conn.
Consolidated Plastics & Mfg. Co., Chicago 10, Ill.
Curry Arts, Scranton 9, Pa.
★D & R Plastic Welders, Inc., Hazardville, Conn.
★Damac Tool Co., Bronx 56, New York
Daniels-Kummer Engraving Co., Addison, Ill.
Dura Plastics of New York, Inc., New York 16, N. Y.
Electromold Corp., Trenton 9, N. J.
Electro Plastics Corp., Dallas 7, Texas
★Engelking Patterns, Inc., Columbus, Ind.
Erinac Equipment Corp., New York 12, N. Y.
Euclid Engineering Co., Upland, Calif.
Evans-Zeier Plastic Co., Madison 4, Wis.
Federal Tool Corp., Chicago 45, Ill.
Ferry Machine Co., Kent, Ohio
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
Garray Plastics, Inc., Kearny, N. J.
Gemloid Corp., Long Island City, N. Y.
General Machine & Tool Works, Walled Lake, Mich.
Gershen, Irvin J., Maplewood, N. J.
★H. M. S. Associates Co., Willow Grove, Pa.
Hartbauer Tool & Die Company, Portland 10, Oregon
Harva Co., The, Inc., Schoharie, N. Y.
Hydro-Chemie, Ltd., Zurich, Switzerland
Industrial Engineering Service, South Easton, Mass.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Industrial Sales Engineers, New York 17, N. Y.
Karlstad, Andrew C., Sherman Oaks, Calif.
Kautex-U. S. Sales Co., Inc., Flushing 54, N. Y.
Keck, Henry, Associates, South Pasadena, Calif.
Ketchpel Engineering Co., W. Englewood, N. J.
★Kingman, E. B., Co., Leominster, Mass.
Kilsey Engineering Co., Los Angeles 23, Calif.
Kreier, George, Jr., Inc., Philadelphia 30, Pa.
Kunst, John, The, Co., New York 7, N. Y.
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass.
Libbert Plastics, Inc., Fort Worth 14, Texas
Lusta-Cite Industries, Inc., Brooklyn 11, N. Y.
Madan Plastics, Inc., Cranford, N. J.
Marscot Plastics, Inc., Fall River, Mass.
Metalmold Forming Co., Brooklyn 1, N. Y.
Mitchell Plastics, Inc., Owosso, Mich.
Mitchell's, L. D., Plastic Studio, Pittsburgh 12, Pa.
Modular Molding Corp., Burlington, N. J.
★Morningstar Corp., The, Cambridge 42, Mass.
Naken, William, Los Angeles 19, Calif.
New England Die Co. Inc., Taunton, Mass.
Nichols Products Co., Inc., Moorestown, N. J.
Norco Plastic, Inc., Milwaukee, Wis.
North Star Industries, Inc., Hopkins, Minn.
Nu-Engineering, Inc., Ferndale 20, Mich.
Oak Engineering Co., Inc., Gloucester City, N. J.
Palisades Plastics Co., Inc., Englewood, N. J.
Pam Company, Portland 9, Ore.
Paragon Plastic Corp., New York 12, N. Y.
Payne Tool & Engineering Co., The, Springfield, Ohio
Peerless Plastics, Culver City, Calif.
Pitman Plastic Products, Inc., Pitman, N. J.
Plastic Age Sales, Inc., Saugus, Calif.
Plastic Corp. of Chicago, Lyons, Ill.
Plastic Enterprises, College Point, N. Y.
Plastic Model Engineering, Van Nuys, Calif.
Plastic Parts Corp., Maumee, Ohio
Plastics by Chapman, Richmond, Calif.
Plastics by Hoover, Huntington, W. Va
Plastics Industries, Inc., Athens, Tenn.
Plastiplate Co., Inc., South River, N. J.
Portz Plastics & Fibre Co., Milwaukee 3, Wis.
Prolon Plastics, Florence, Mass.
Reinhardt Plastics Co., Denver 2, Colo.
Reynolds Plastics, Inc., Walled Lake, Mich.
Rochelle Plastic Mold Co., Inc., Clifton, N. J.
Roger's Product Design, Leominster, Mass.
Romar Plastics, Inc., St. Charles, Ill.
S-K-W Mfg. Co., Chicago 30, Ill.
Sarcol Foundry & Pattern Corp., Chicago 12, Ill.
Sawaya Manufacturing Co., Inc., Trinidad, Colo.
Schur-Appel Design, Short Hills, N. J.
Schramm Fiberglass Products, Inc., Chicago 18, Ill.
Seder Plastic Corp., Ft. Collins, Colo.
Sharpe Plastics, Inc., Sudbury, Mass.
Sidco, N. Plainfield, N. J.
Singer, Lawrence H., New York 17, N. Y.
★Sinko Mfg. & Tool Co., Chicago 31, Ill.
Sossner Steel Stamps, Inc., New York 13, N. Y.
Southern Plastic Products Co., Riviera Beach, Fla.
South Salem Studios, S. Salem, N. Y.
★Standard Tool Co., Leominster, Mass.
Stensgaard, W. L., & Associates, Inc., Chicago 7, Ill.
Stricker-Brunhaber Corp., New York 10, N. Y.
Stricker, Carl, Mechanical Developer, Bloomfield, N. J.
★Superior Plastics, Inc., Chicago 12, Ill.

★Indicates Advertiser

Syracuse Plastic Molders, Syracuse 2, N. Y.
Technicraft Co., Boston 34, Mass.
★Thierica Studio, Inc., Grand Rapids 5, Mich.
Rafael Triana, New York 32, N. Y.
Vacuum Plastics Corp., Columbus 22, Ohio
Wama Co., The, Baltimore 2, Md.
★Waterbury Companies, Inc., Waterbury, Conn.
Wess Plastic Molds, Inc., New Hyde Park, N. Y.

MOLD CAVITY CASTING

A. Aluminum
B. Beryllium Copper
C. Ferrous Metals
D. Plastics
E. Steel

Accurate Match Plate Co., Inc., Chicago 12, Illinois (A)
Ace Plastic Molding Corp., Long Island City 1, N. Y. (B, E)
Advance Molded Plastics Corp., Chicago 39, Ill. (B, D)
Air-Formed Products Corp., Nashua, N. H. (A)
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio (A, B)
American Agile Corp., Bedford, Ohio (D)
Astor Tool & Die Co., Long Island City 1, N. Y. (A, B, C, E)
Atlantic Mfg. Co., Philadelphia 22, Pa. (A, B, C, D, E)
★Atols Tool & Mold Corp., Chicago 39, Ill. (C)
Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (D)
Bacon & Weber, Chicago 22, Ill. (D)
Brilhart Plastics Corp., Mineola, N. Y. (D)
★Cadillac Plastic & Chemical Co., Detroit 3, Mich. (D)
Chaney Plastic Molding Co., Denver 16, Colo. (D)
Columbia Basin Plastics Co., Portland 1, Ore. (D, E)
Contour Packaging Co., Philadelphia 27, Pa. (D)
Crucible Steel Co. of America, Pittsburgh 30, Pa. (C, E)
Cuming & Co., Inc., M. A., New York 12, N. Y. (A, C)
Damen Tool & Engineering Co., Inc., Chicago 31, Ill. (B, C, E)
Daniels-Kummer Engraving Co., Addison, Ill. (A, B, C, D, E)
Disogrin Industries, Inc., Mt. Vernon, N. Y. (D)
Electro Plastics Corp., Dallas 7, Texas (E)
Electromold Corp., Trenton 9, N. J. (D)
Federal Tool Corp., Chicago 45, Ill. (B)
Garray Plastics, Inc., Kearny, N. J. (D)
★General Industries Co., The, Elyria, Ohio (A, B, C, E)
General Machine & Tool Works, Walled Lake, Mich. (D)
Hanley Plastics Co., St. Louis 17, Mo. (D)
★Harvey, Guy P., & Son Corp., Leominster, Mass. (B)
High Strength Plastics Corp., Chicago 7, Ill. (D)
Houghton Laboratories, Inc., Olean, N. Y. (D)

★Indicates Advertiser

Hydro-Chemie, Ltd., Zurich, Switzerland (A, C)
Klisey Engineering Co., Los Angeles 23, Calif. (A, C, D, E)
Kreier, George, Jr., Philadelphia 30, Pa. (D)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (D)
Leominster Tool Co., Inc., Leominster, Mass. (C)
Leon Machine & Engineering Co., Riverside, N. J. (A)
Libbert Plastics, Inc., Fort Worth 14, Texas (D)
Maine Molding Products, Boothbay Harbor, Maine (A, B, C, D, E)
Manco Products, Inc., Melvindale, Mich. (A, B, C, E)
Many & Co., J., New York 13, N. Y. **(B, C, E)**
Marscot Plastics, Inc., Fall River, Mass. (D)
Metalmold Forming Co., Brooklyn 1, N. Y. (A, D)
★Midwest Pressure Casting Co., Chicago 8, Ill. (A)
Modular Molding Corp., Burlington, N. J. (D)
Moldcraft, Inc., Baltimore, 11, Md. (E)
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio (D)
★Newark Die Co., Newark 2, N. J. (B, E)
★Newark Die, Hobbing & Casting Co., Newark 2, N. J. (B, E)
Payne Tool & Engineering Co., The, Springfield, Ohio (A, B, C, E)
Pitman Plastic Products, Inc., Pitman, N. J. (D)
Plastex Laminates, Inc., Hialeah, Fla. (D)
Plasti-Skill Co., Corona 68, N. Y. (D)
Plastic Corp. of Chicago, Lyons, Ill. (D)
Plastic Mold Tool & Die Co., Inc., E. Rutherford, N. J. (B, E)
Precision Plastics Co., Philadelphia 44, Pa. (B, C, E)
Process Mold Co., Detroit 5, Mich. (A, B, C)
Randazzo Plastic Co., Inc., Los Angeles 47, Calif. (C, E)
Reinhardt Plastics Co., Denver 2, Colo. (C)
Reynolds Plastics, Inc., Walled Lake, Mich. (D)
Rochelle Plastic Mold Co., Inc., Clifton, N. J. (A, B)
Sarcol Foundry & Pattern Corp., Chicago 12, Ill. (A, E)
Scientific Cast Products Corp. of Illinois, Chicago 12, Ill. (A)
Sidco, N. Plainfield, N. J. (D)
★Sierra Electric Corp., Gardena, Calif. (B)
Southern Plastic Products Co., Riviera Beach, Fla. (D)
South Salem Studios, South Salem, N. Y. (D)
Springfield Cast Products, Inc., Springfield 9, Mass. (A)
★Standard Tool Co., Leominster, Mass. (A, B, C, E)
★Superior Plastics, Inc., Chicago 12, Ill. (B, D)
Syracuse Plastic Molders, Syracuse 2, N. Y. (A, D)
Ultra Electroforming & Mfg., Pitman 7, N. J. (D)
Vacuum Plastics Corp., Columbus 22, Ohio (D)
Vanadium-Alloys Steel Co., Latrobe, Pa. (E)
Voges Mfg. Co., Inc., Ozone Park 17, N. Y. (A, B, C, D, E)

MOLD MAKING

A. Electroforming
B. Metal Spraying
C. Reinforced Plastics
D. Rubber (See also Bags, Vacuum and Pressure, p. 1136)
E. Steel

ABA Tool & Die Co., Inc., Manchester, Conn. (A, E)
A. S. K. Plastic Mfg. Co., Philadelphia 22, Pa. (E)
Ace Plastic Molding Corp., Long Island City 1, N. Y. (E)
Ace Tool & Manufacturing Co., Newark 5, N. J. (E)
Adams Plastic Products, Cincinnati 14, Ohio (E)
Advance Molded Plastics Corp., Chicago 39, Ill. (E)
Air-Formed Products Corp., Nashua, N. H. (E)
Akromold, Inc., Akron 1, Ohio (E)
★Akron Presform Mold Co., The, Cuyahoga Falls, Ohio (A, B, C, D, E)
Akron Standard Mold Co., The, Akron 5, Ohio (E)
All-Tech Industries, Inc., Miami 68, Fla. (C)
Allied Mfg. Co., Seattle 44, Wash. (E)
Allied Plastic Mold, Inc., Lodi, N. J. (E)
Anderson Die & Mfg. Co., Portland 19, Ore. (E)
Anson Tools & Gages, Inc., Erie, Pa. (E)
★Artag Plastics Corp., Chicago 18, Ill. (E)
Astor Tool & Die Co., Long Island City 1, N. Y. (A, B, E)
Atkins & Merrill, Inc., Reinforced Plastics Div., Marlboro, Mass. (C)
Atlantic Mfg. Co., Philadelphia 22, Pa. (C, E)
Atlas Plastics, Inc., Little Ferry, N. J. (E)
★Atols Tool & Mold Corp., Chicago 39, Ill. (C, E)
★Auburn Plastics, Inc., Auburn, N. Y. (E)
Axel Plastics Research Laboratories, Brooklyn 22, N. Y. (C)
★B & E Electroform Co., Union, N. J. (A, E)
Baco Co., New York 13, N. Y. (E)
Bacon & Weber, Chicago 22, Ill. (C)
Bart Manufacturing Corp., Belleville 9, N. J. (A)
Beacon Die-Mold, Inc., Clifton, N. J. (A, E)
Beazy's Moldmakers, Peru, Ind. (C, E)
★Becker & Van Hüllen, Krefeld, West Germany (E)
Beel Engineering Co., Newark 2, N. J. (E)
Bergen Mold & Engineering, Little Ferry, N. J. (E)
Bernard Plastics Molding Corp., Long Island City 1, N. Y. (E)
★Blackhawk Molding Co., Inc., Addison, Ill. (A, E)
Bondy Engineering Co., Brooklyn 17, N. Y. (E)
Bostrom Corp., Milwaukee 4, Wis. (C)
Bricmar Mfg. Corp., New York 13, N. Y. (B, D)
Brilhart Plastics Corp., Mineola, N. Y. (C, E)
★Brunswick-Balke-Collender Co., Defense Products Div., Muskegon, Mich. (B, C)

Buttondex Corp., N. Y. 16, N. Y. (E)
★Capitol Plastics Co., Lansing, Mich. (C)
Chaney Plastic Molding Co., Denver 16, Colo. (E)
Chemtron Fiber Glass Co., El Monte, Calif. (C, D, E)
★Chicago Mold Engineering Co., Inc., Westchester, Ill. (E)
Columbia Basin Plastics Co., Portland 1, Ore. (E)
★Conforming Matrix Corp., Toledo 2, Ohio (A)
Cook, Lawrence H., Inc., E. Providence 14, R. I. (E)
Cowan Boyden Corp., Providence 9, R. I. (E)
Crucible Steel Co. of America, Pittsburgh 30, Pa. (E)
Cumberland Tool Works, Chicago 22, Ill. (E)
Cuming & Co., Inc., M. A., New York 12, N. Y. (C, D)
★Damac Tool Co., Bronx 56, N. Y. (C, E)
Damen Tool & Engineering Co., Inc., Chicago 31, Ill. (A, C, E)
Daniels-Kummer Engraving Co., Addison, Ill. (E)
Decatur Plastic, Inc., Decatur, Alabama (E)
Delkay Plastics Corp., Gardena, Calif. (E)
Diemolding Corp., Canastota, N. Y. (E)
E-W Mold & Tool Co., Inc., Indianapolis 6, Ind. (B, E)
Eastern Plastics Co., Inc., N. Wilbraham, Mass. (C, E)
Electro Plastics Corp., Dallas 7, Texas (E)
Electroforms, Inc., Gardena, Calif. (A, B)
Electromold Corp., Trenton 9, N. J. (A)
Enduro Tool & Engineering Co., Chicago 51, Ill. (E)
★Engelking Patterns, Inc., Columbus, Ind. (C, E)
Erinac Equipment Corp., New York 12, N. Y. (E)
Euclid Engineering Co., Upland, Calif. (E)
Evans-Zeier Plastic Co., Madison 4, Wis. (E)
Excel-Mold, Inc., Indianapolis 3, Ind. (E)
F & F Mold & Die Works, Inc., Dayton, Ohio (E)
Fawn Plastics Co., Inc., Timonium, Md. (E)
Fischer, Johann, Maschinenbau, Lohmar, Bez., Cologne, West Germany (E)
Fortney Mfg. Co., Inc., Newark 5, N. J. (E)
★Garfield Mfg. Co., Wallington, N. J. (E)
Garry Plastics, Inc., Kearny, N. J. (E)
Gemloid Corp., L. I. C., N. Y. (E)
★General American Transportation Corp., Plastics Div., Chicago 90, Ill. (E)
General Die Mold Co., Chicago 12, Ill. (E)
★General Industries Co., The, Elyria, Ohio (C, E)
General Machine & Tool Works, Walled Lake, Mich. (C, E)
Geneve Mfg. Corp., Trenton, N. J. (A)
Gibson Associates, Inc., Cranford, N. J. (E)
Gidion's, Milan, Italy (E)
Gougler Machine Co., C. L., Kent, Ohio (E)
Guild Molders, Inc., Elmsford, N. Y. (E)
Gulliksen Mfg. Co., Wm. H., Newton Lower Falls 62, Mass. (E)
Hake Manufacturing Co., Inc., Roanoke, Va. (E)
Hanley Plastics Co., St. Louis 17, Mo. (C)
Hartbauer Tool & Die Company, Portland 10, Oregon (E)
Hartland Plastics Inc., Hartland, Wis. (A)
★Harvey, Guy P. & Son Corp., Leominster, Mass. (C, E)
Haveg Industries, Inc., Wilmington 8, Del. (C)
Hedrix Co., Frank, Paramount, Calif. (E)
Helmuth Tool & Die Co., Linden, N. J. (E)
High Strength Plastics Corp., Chicago 7, Ill. (C)
Houghton Laboratories, Inc., Olean, N. Y. (C)
Industrial Development Laboratories, Inc., Edgewater, N. J. (E)
Industrial Engineering Service, South Easton, Mass. (E)
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn. (C)
★Jay Co., T. V., Chicago 18, Ill. (A)
Kellering, Victor, Inc., Brooklyn 3, N. Y. (C, E)
Kerrco Products, Lincoln 7, Neb. (C, D, E)
★Kingman Co., E. B., Leominster, Mass. (E)
Kreier, George, Jr., Inc., Philadelphia 30, Pa. (C)
Kunst Co., John, The, New York 7, N. Y. (D, E)
Lami-Plast Products Co., Tampa 3, Fla. (C)
Lawrence Adhesive & Chemical Co., Inc., Lawrence, Mass. (C)
Leominster Tool Co., Inc., Leominster, Mass. (E)
Libbert Plastics, Inc., Fort Worth 14, Texas (E)
★Liberty Tool & Machine Co., Irvington 11, N. J. (E)
Liss Products, Inc., Grasmore, N. H. (C)
Lunn Laminates, Inc., Huntington Station, N. Y. (C)
Maine Molding Products, Boothbay Harbor, Maine (C, E)
Many & Co., J., New York 13, N. Y. (E)
Marscot Plastics, Inc., Fall River, Mass. (C)
Martindell Molding Co., Trenton 2, N. J. (E)
Master Molded Products Corp., Skokie, Ill. (E)
Metalmold Forming Co., Brooklyn 1, N. Y. (B)
Microcell, Ltd., London W.C. 2, England (C)
★Midland Die & Engraving Co., Franklin Park, Ill. (E)
Modern Designers, Hialeah, Fla. (E)
Modern Tool & Die Co., Inc., Leominster, Mass. (E)
Modular Molding Corp., Burlington, N. J. (C)
Moldcraft, Inc., Baltimore 11, Md. (E)
★Mold Duplicating Co., Kenilworth, N. J. (E)
Moldex, Yonkers, N. Y. (E)
Mueller, Ernest, Los Angeles 36, Calif. (A, B)
Nalle Plastics, Inc., Austin 1, Tex. (E)
New England Die Co. Inc., Taunton, Mass. (D, E)
★Newark Die Co., Newark 2, N. J. (B, E)
★Newark Die, Hobbing & Casting Co., Newark 2, N. J. (B, C)
Niles Corp., South Bend 17, Ind. (E)
Norco Plastic Inc., Milwaukee, Wis. (E)
North Star Industries, Hopkins, Minn. (E)
Nu-Engineering, Inc., Ferndale 20, Mich. (E)
Oak Engineering Co. Inc., Gloucester City, N. J. (A, C, E)
Oakley Die & Mfg. Co., Inc., The, Cincinnati 9, Ohio (E)
Palfy Die & Mold Co., The, Cleveland 29, Ohio (E)
Paragon Plastic Corp., New York 12, N. Y. (E)
Parker Plastics Corp., Pittsburgh 34, Pa. (E)
Pasley's Plastic Products, Inc., Atlanta 18, Ga. (A)
Peerless Plastics, Culver City, Calif. (E)
Pitman Plastic Products, Inc., Pitman, N. J. (B, C)
Planet Plating Co. Inc., Brooklyn 22, N. Y. (A)
Plano Molding Co., Plano, Ill. (E)
★Plas-Tool Co., Skokie, Ill. (E)
Plasti-Skill Co., Corona, 68, N. Y. (C, D)
Plastic Corp. of Chicago, Lyons, Ill. (B, C)
Plastic Engineering Co., Pawtucket, R. I. (E)
Plastic Enterprises, College Point, N. Y. (C)
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga. (C)
Plastic Mold and Tool Co., Philadelphia 35, Pa. (E)
Plastic Mold Tool & Die Co., Inc., E. Rutherford, N. J. (A, E)
Plastic Precision Parts Co., Chicago 39, Ill. (E)
Plastics, Inc., St. Paul 5, Minn. (E)
Plastiplate Co., Inc., South River, N. J. (A)
★Plating Engineering Co., Milwaukee 19, Wis. (A)
Primas Moldmakers, Inc., Buffalo 11, N. Y. (E)
Plura Plastics, Maplewood, N. J. (E)
Process Mold Co., Detroit 5, Mich. (E)
Prodel, S.A., Societe De Produits Industriels, Paris 16, France
Rainbow Plastic Products, Inc., Minneapolis 16, Minn. (E)
Randazzo Plastic Co., Inc., Los Angeles 47, Calif. (E)
Rayette, Inc., St. Paul 1, Minn. (E)
Reinhardt Plastics Co., Denver 2, Colo. (A)
Reinhold-Geiger Plastics, Inc., Los Angeles 3, Calif. (E)
Reynolds Plastics, Inc., Walled Lake, Mich. (C, D)
Rochelle Plastic Mold Co., Inc., Clifton, N. J. (A, E)
Rosbro Plastics Corp., Pawtucket, R. I. (E)
Rosenthal, Alfred A., New York 38, N. Y. (E)
S-K-W Mfg. Co., Chicago 30, Ill. (E)
Santay Corp., Chicago 24, Ill. (E)
Sarcol Foundry & Pattern Corp., Chicago 12, Ill. (C, D, E)
Sawaya Manufacturing Co., Inc., Trinidad, Colo. (A, C)
Schramm Fiberglass Products, Inc., Chicago 18, Ill. (C)
Schwarzfaerber & Co., G.m.b.H., Nürnberg, West Germany (E)

★Indicates **Advertiser**

Seymour, S. R., & Co., Ltd., Rayleigh, Essex, England (E)
Shaw Industries, Inc., Franklin, Pa. (C, E)
Sheller Mfg. Corp., Portland, Ind. (E)
Sidco, N. Plainfield, N. J. (D)
★Sierra Electric Corp., Gardena, Calif. (A, C, E)
★Sinko Mfg. & Tool Co., Chicago 31, Ill. (E)
Southern Plastic Products Co., Riviera Beach, Fla. (C)
South Salem Studios, South Salem, N. Y. (B, C)
Sperzel Co., Minneapolis 8, Minn. (E)
Springfield Cast Products, Inc., Springfield 9, Mass. (E)
Springfield Tool & Die Co., Inc., Springfield, N. J. (E)
★Standard Tool Co., Leominster, Mass. (E)
Sterling Plastics Co., Union, N. J. (E)
Stokes-Trenton, Inc., Trenton 9, N. J. (A, E)
Strabeg Machine Co., New York 54, N. Y. (E)
Stricker-Brunhaber Corp., New York 10, N. Y. (C, D, E)
Sun Plastics, Inc., Cuyahoga Falls, Ohio (E)
★Superior Plastics, Inc., Chicago 12, Ill. (E)
Tech-Art Plastics Co., Morristown, N. J. (E)
Tillinghast Associates of Germany, Fullerton, Calif. (E)
★Tilp, J. G., Inc., Union, N. J. (E)
Timely Products Co., Des Moines 15, Iowa (A)
Tri-State Plastic Molding Co., Henderson, Ky. (E)
Ultra Electroforming & Mfg., Pitman 7, N. J. (A)
United Fabricators & Electronics, Inc., Stillwater, Minn. (E)
Vanadium-Alloys Steel Co., Latrobe, Pa. (E)
Victory Plastics Co., Hudson Co. (C, E)
★Waterbury Companies, Inc., Waterbury, Conn. (E)
Welch Plastics & Mfg. Co., Inc., Columbus 8, Ohio (E)
Westech Engineering, Santa Clara, Calif. (C, E)
Western Coil & Electrical Co., Racine, Wis. (E)
Wittman, Lawrence, & Co., Massapequa, N. Y. (C)

MOLD POLISHING (Only)

ABA Tool & Die Co., Inc., Manchester, Conn.
Acme Scientific Co., Chicago 7, Illinois
Anson Tools & Gages, Inc., Erie, Pa.
Atlantic Mfg. Co., Philadelphia 22, Pa.
Bondy Engineering Co., Brooklyn 17, N. Y.
★Chromium Corp. of America, New York 17, N. Y.
Damen Tool & Engineering Co., Inc., Chicago 31, Ill.
Daniels-Kummer Engraving Co., Addison, Ill.
E-W Mold & Tool Co., Inc., Indianapolis 6, Ind.
Euclid Engineering Co., Upland, Calif.
Hake Mfg. Co., Inc., Roanoke, Va.
★Liberty Tool & Machine Co., Irvington 11, N. J.
Many, J., & Co., New York 13, N. Y.
Micron Specialties Co., Chicago 39, Ill.
Mold Polishing Service, Riverdale, N. J.
★Newark Die Co., Newark 2, N. J.
New England Die Co., Inc., Taunton, Mass.
Nutmeg Chrome Corp., W. Hartford 10, Conn.
Payne Tool & Engineering Co., The, Springfield, Ohio
Plastic Mold Tool & Die Co., Inc., E. Rutherford, N. J.
Rochelle Plastic Mold Co., Inc., Clifton, N. J.
★Standard Tool Co., Leominster, Mass.
Stokes-Trenton, Inc., Trenton 9, N. J.
Stricker-Brunhaber Corp., New York 10, N. Y.
Techline Div., Wheelabrator Corp., Vicksburg, Mich.

PANTOGRAPHING AND KELLERING

A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
ABA Tool & Die Co., Inc., Manchester, Conn.
Ace Plastic Molding Corp., Long Island City 1, N. Y.
Air-Formed Products Corp., Nashua, N. H.
Akron Standard Mold Co., The, Akron 5, Ohio
Alda Plastics, Inc., New York 13, N. Y.
Allied Engravers, Inc., New York 12, N. Y.
Allied Plastic Mold, Inc., Lodi, N. J.
Allied Plastics Supply Corp., New York 38, N. Y.
Anson Tools & Gages, Inc., Erie, Pa.
Artmor Plastics Corp., Cumberland, Md.
Astor Tool & Die Co., Long Island City 1, N. Y.
Atlantic Mfg. Co., Philadelphia 22, Pa.
★Atols Tool & Mold Corp., Chicago 39, Ill.
★B & E Electroform Co., Union, N. J.
Beacon Die-Mold, Inc., Clifton, N. J.
Bolling Industries, Inc., Scranton 5, Pa.
★Chicago Mold Engineering Co., Inc., Westchester, Ill.
Clear View Plastics Corp., Poplar Bluff, Mo.
★Colonial Kolonite Co., Chicago 47, Ill.
Conn-Craft Co., Waterbury 5, Conn.
Crystal-X Corp., Lenni Mills, Pa.
Crystal Plastic, Inc., Brooklyn 5, N. Y.
★Damac Tool Co., Bronx 56, New York
Damen Tool & Engineering Co., Inc., Chicago 31, Ill.
Daniels-Kummer Engraving Co., Addison, Ill.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
E-W Mold & Tool Co., Inc., Indianapolis 6, Ind.
★Engelking Patterns, Inc., Columbus, Ind.
Erinac Equipment Corp., New York 12, N. Y.
Euclid Engineering Co., Upland, Calif.
Evans-Zeier Plastic Co., Madison 4, Wis.
Excel-Mold, Inc., Indianapolis 3, Ind.
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
★General American Transportation Corp., Plastics Div., Chicago 90, Ill.
General Machine & Tool Works, Walled Lake, Mich.
Har-E-Dan Engravers, Brooklyn 8, N. Y.
Harva Co., The, Inc., Schoharie, N. Y.
Helmuth Tool & Die Co., Linden, N. J.
Kellering, Victor, Inc., Brooklyn 3, N. Y.
Libbert Plastics, Inc., Fort Worth 14, Texas
Lustra-Cite Industries, Inc., Brooklyn 11, N. Y.
Mechanical Engraving Co., Inc., New York 68, N. Y.
Moldcraft, Inc., Baltimore 11, Md.
★Mold Duplicating Co., Kenilworth, N. J.
★Newark Die Co., Newark 2, N. J.
New England Die Co., Inc., Taunton, Mass.
Palfy Die & Mold Co., The, Cleveland 29, Ohio
Payne Tool & Engineering Co., The, Springfield, Ohio
Pierce Wrapping Machine Co., La Grange Pk., Ill. (Chicago Suburb)
Plastic-Craft Products Corp., West Nyack, N. Y.
Plastic Engineering Co. of Tulsa, Tulsa, Okla.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastic Mold and Tool Co., Philadelphia 35, Pa.
Plastic Mold Tool & Die Co., Inc., E. Rutherford, N. J.
Plastic Suppliers and Manufacturers, Baton Rouge, La.
Plastics by Chapman, Richmond, Calif.
Plura Plastics, Maplewood, N. J.
Queen Products, Inc., Providence 5, R. I.
Rochelle Plastic Mold Co., Inc., Clifton, N. J.
Sawaya Mfg. Co., Inc., Trinidad, Colo.
Sharpe Plastics, Inc., Sudbury, Mass.
Shaw Industries, Inc., Franklin, Pa.
Sossner Steel Stamps, Inc., New York 13, N. Y.
Stokes-Trenton, Inc., Trenton 9, N. J.
Strabeg Machine Co., New York 54, N. Y.
Stricker-Brunhaber Corp., New York 10, N. Y.
Wama Co., The, Baltimore 2, Md.
Western Coil & Electrical Co., Racine, Wis.

PERFORATING PLASTIC SHEETING

Aacon Industries, Inc., Brooklyn 24, N. Y.
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J.
★Blank, Arthur, & Co., Inc., Boston 15, Mass.
★Carroll, J. B., Co., Chicago 12, Ill.
Chemicraft Corp., New York 1, N. Y.
Contour Packaging Co., Philadelphia 27, Pa.
Electro-Chemical Products, Cleveland 10, Ohio
★Emeloid Co., The, Inc., Hillside 5, N. J.
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
G & S Label Corp., New York 1, N. Y.
Lamex, Inc., Norcross, Ga.
Laminated Sheet Products Corp., Norwood, Mass.
Lus-Trus Corp., Ypsilanti, Mich.
Madan Plastics, Inc., Cranford, N. J.
Payne Tool & Engineering Co., The, Springfield, Ohio
Pen Mac Nye Co., The, Akron 10, Ohio
★Perforated Specialties Co., New York 1, N. Y.

★Indicates Advertiser

★Perforating Industries, Inc., Roselle Park, N. J.
Printon Corp., New York 10, N. Y.
Pyramid Screen Corp., Brookline 46, Mass.
Shamban & Co., W. S., Culver City, Calif.
★Sillcocks Miller Co., The, Maplewood, N. J.
Usines Gheysen, S.A., Lembecq-Hal, Belgium
Woodall Industries, Inc., Detroit 34, Mich.

PLATING MOLDS, RAMS, AND PLATES

(Hard Chromium)

Astor Tool & Die Co., Long Island City 1, N. Y.
★Chromium Corp. of America, New York 17, N. Y.
Damen Tool & Engineering Co., Inc., Chicago 31, Ill.
Diamond Hard Chromium Co., Inc., Newark, New Jersey
Har-Conn Chrome Co., West Hartford 10, Conn.
Industrial Engineering Service, South Easton, Mass.
Industrial Hard Chromium Co., Newark, N. J.
★Jay Co., T. V., Chicago 18, Ill.
Micron Specialties Co., Chicago 39, Ill.
Nutmeg Chrome Corp., West Hartford 10, Conn.
Sawaya Mfg. Co., Inc., Trinidad, Colo.
★U. S. Metal Coatings Co., Inc., Middlesex, N. J.

POSTFORMING OF LAMINATES

Brandywine Fibre Products Co., Wilmington, Del.
Chemtron Fiber Glass Co., El Monte, Calif.
Chicago Plastic Products Co., Inc., Chicago 10, Ill.
Curry Arts, Scranton 9, Pa.
★Emeloid Co., The, Inc., Hillside 5, N. J.
Emerson Plastics Corp., Bronx 61, N. Y.
★Engineered Plastics, Inc., Gibsonville, N. C.
Fabri-Form Co., The, Byesville, Ohio
Formica Corp., The, Cincinnati 32, Ohio
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
General Plastics Mfg. Co., Tacoma 2, Wash.
Insulating Fabricators of New England, Inc., Watertown 72, Mass.
Laminated Sheet Products Corp., Norwood, Mass.
Lone Star Plastics Co., Inc., Fort Worth, Texas
Long, Thomas J., Inc., Carle Place, N. Y.
Modular Molding Corp., Burlington, N. J.
★New England Laminates Co., Inc., Stamford, Conn.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastics Industries, Inc., Athens, Tenn.
Reynolds Plastics, Inc., Walled Lake, Mich.
Roysons, Inc., Cedar Grove, N. J.
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y.
★Sierra Electric Corp., Gardena, Calif.
Silicone Insulation, Inc., Bronx 61, N. Y.

Southern Plastic Products Co., Riviera Beach, Fla.
★Swedlow, Inc., Los Angeles, Calif.
Usines Gheysen, S.A., Lembecq-Hal, Belgium
Western Coil & Electrical Co., Racine, Wis.
Westech Engineering, Santa Clara, Calif.
Woodall Industries, Inc., Detroit 34, Mich.

PRESS POLISHING

Acme Laminating & Plastics Co., Inc., Detroit, Mich.
American Hard Rubber Co., Div. of Amerace Corp., Butler, N. J.
★Blank & Co., Arthur, Inc., Boston 15, Mass.
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que.
Curry Arts, Scranton 9, Pa.
★Davis, Joseph, Plastics Co., Kearny, N. J.
★Emeloid Co., Inc., The, Hillside 5, N. J.
General Machine & Tool Works, Walled Lake, Mich.
★Hopp Plastics, Div. of the Hopp Press, Inc., New York 1, N. Y.
Kaykor Industries, Inc., Yardville, N. J.
Leathertone, Inc., Boston 14, Mass.
Plastic Laminating Corp., Vauxall, N. J.
Plastic Service Corp., New York 10, N. Y.
Polyplastex United, Inc., Union, N. J.
★Portage Plastics Co., Portage, Wis.
Plastics by Chapman, Richmond, Calif.
Printloid, Inc., Long Island City 1, N. Y.
Reiss Associates, Lowell, Mass.
Roltex Process Corp., Roselle, N. J.
Rowland Products, Inc., Kensington, Conn.
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y.
★Sillcocks Miller Co., The, Maplewood, N. J.
Teitelbaum Sons, N., Inc., New York 51, N. Y.
Usines Gheysen, S. A., Lembecq-Hal, Belgium
Victory Plastics Co., Hudson, Mass.
Virginia Plak Co., New York 16, N. Y.

PRINTING

A. Flexible Plastic Film and Sheeting
B. Rigid Plastic Sheets
C. Finished Plostic Products (Bottles, Novelties, etc.)

A.A.A. Plastic Co., New York 17, N. Y. (B, C)
Aacon Industries, Inc., Brooklyn 24, N. Y. (A, B, C)
Accurate Gold Stamping Co., Inc., New York 11, N. Y. (A, C)
Acme Laminating & Plastics Co., Inc., Detroit, Mich. (B)
★Acromark Co., The, Elizabeth 4, N. J. (C)
Allegheny Plastics, Inc., Coraopolis, Pa. (A, B)
Ambassador Arts, New York 11, N. Y. (A, B, C)
American Plasticraft Co., New York 61, N. Y. (C)
Ameriplastic Co., The, Flint 7, Mich. (A, B, C)
★Amos Molded Plastics Div., Amos-Thompson Corp., Edinburg, Ind. (C)
Art Decorating Co., North Bergen, N. J. (B, C)
Associated Rubber & Plastic Corp., New York 51, N. Y. (A)
Austin Industries, Inc., Marlboro, Mass. (A)
Bedford Products, Inc., Roanoke, Va. (C)
★Blank & Co., Arthur, Inc., Boston 15, Mass. (B)
Bolling Industries, Inc., Scranton 5, Pa. (C)
Brockton Plastics, Inc., Brockton, Mass. (A, B)
Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal 2, Que. (A)
Canton Containers, Inc., Canton 7, Ohio (A)
★Carroll, J. B., Co., Chicago 12, Ill. (B)
Chaney Plastic Molding Co., Denver 16, Colo. (C)
Coating Products, Inc., Englewood, N. J. (A)
Colvin-Friedman Co., Springfield, N. J. (B)
Commercial Plastics Co., Chicago 14, Ill. (A, B, C)
★Cosom Engineering Corp., Minneapolis 16, Minn. (C)
Cowan Boyden Corp., Providence 9, R. I. (C)
Cromwell Paper Co., Chicago 1, Ill. (A)
Crystal-X Corp., Lenni Mills, Pa. (A, B, C)
Decotone Products Div., Fitchburg Paper Co., Fitchburg, Mass. (A)
Defiance Machine & Tool Co., St. Louis 10, Mo. (A, B)
Dennison Mfg. Co., Framingham, Mass. (C)
Dumais Co., Joseph F., Fall River, Mass. (C)
Dura-Lee Corp., Kansas City 5, Mo. (A)
Electro Plastics Corp., Dallas 7, Texas (B)
★Emeloid, Co., Inc., The, Hillside 5, N. J. (B, C)
Equitable Paper Bag Co., Inc., Long Island City 1, N. Y. (A)
Fair Martin Boxes, Inc., Concord, N. C. (A)
Fassler & Co., Inc., M. J., Brooklyn 21, N. Y. (A)
Federal Tool Corp., Chicago 45, Ill. (C)
Flexcon Co., Spencer, Mass. (A, B)
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio (A)
Franklin Fibre-Lamitex Corp., Wilmington 99, Del. (B, C)
G & S Label Corp., New York 1, N. Y. (A)
General Research & Supply Co., Grand Rapids 3, Mich. (B)
Gits Molding Corp., J. P., Chicago 44, Ill. (C)
Goodren Products Corp., Englewood, N. J. (A, B, C)
Gordon-Lacey Chemical Products, Inc., Maspeth 78, N. Y. (A)
Gotham Plastics Corp., Bronx 51, N. Y. (B, C)
Hastings & Co., Inc., Philadelphia 3, Pa. (A)
★Hopp Plastics, Div. of the Hopp Press, Inc., New York 1, N. Y. (B)
Hy-Sil Mfg. Co., Revere, Mass. (A)

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Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn. (C)
Industrial Sales Engineers, New York 17, N. Y. (A, B, C)
International Eastern Co., New York 1, N. Y. (C)
Jacobson, S. I., Mfg. Co., Chicago 5, Ill. (A)
Kaumagraph Co., Wilmington 99, Del. (B)
Kehr Products Co., Philadelphia 8, Pa. (A)
Keystone Packaging Service, Easton, Pa. (A)
★Kingman Co., E. B., Leominster, Mass. (C)
Landers Corp., The, Toledo 1, Ohio (A)
Leathertone, Inc., Boston 14, Mass. (A, B)
Leedpak, Inc., New York 1, N. Y. (A, B, C)
Madan Plastics, Inc., Cranford, N. J. (B, C)
Malco Plastics, Inc., Baltimore 15, Md. (B)
Mankato Paper Box Co., Mankato, Minn. (B)
Marbek, Inc., Brooklyn 22, N. Y. (A)
Moldcraft, Inc., Baltimore 11, Md. (C)
Monoplastics, Inc., Georgetown, Conn. (C)
Monkley Corp., Worcester 8, Mass. (A)
Motson Co., J. Frank, Flourtown, Pa. (B, C)
Multicraft, Inc., Hillside, Ill. (B, C)
Nashua Corp., Nashua, N. H. (A)
New England Laboratories, Inc., Ipswich, Mass. (A, B, C)
Niagara Plastics Co., Erie, Pa. (C)
Olympic Plastics Co., Inc., Los Angeles 16, Calif. (C)
O'Sullivan Rubber Corp., Winchester, Va. (A)
Parker Plastics Corp., Pittsburgh 34, Pa. (C)
Permanent Label Corp., Bloomfield, N. J. (B, C)
Perma Seal Plastic Products Co., St. Paul 4, Minn. (B, C)
Plastic Film Co., Inc., New York, N. Y. (A)
Plastic Masters, Inc., New Buffalo, Mich. (C)
Plastic Suppliers and Manufacturers, Baton Rouge, La. (A, B)
Plastics by Chapman, Richmond, Calif. (B)
Poly Plastic Products, Inc., Paterson 4, N. J. (A)
★Possis Machine Corp., Minneapolis 3, Minn. (C)
Premier Plastics Co., Milwaukee 4, Wis. (B, C)
Printloid, Inc., Long Island City 1, N. Y. (B)
Printon Corp., New York 10, N. Y. (A, B)
Protective Lining Corp., Brooklyn 31, N. Y. (A)
Rainbow Plastic Products, Inc., Minneapolis 16, Minn. (C)
Ridge Printing Co., Inc., Ridgefield, N. J. (A)
★Riegel Paper Corp., New York 17, N. Y. (A)
Roltex Process Corp., Roselle, N. J. (A)
Roysons, Inc., Cedar Grove, N. J. (A)
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y. (A, B)
S-L-M Plastics, Avenel, N. J. (A)
Sawaya Manufacturing Co., Inc., Trinidad, Colo. (A, B)
Screen-O-Printer Mfg. Co., Adams, Mass. (A, B, C)
★Sillcocks Miller Co., The, Maplewood, N. J. (A, B, C)
★Sinko Mfg. Co., Chicago 31, Ill. (C)
Southern Plastic Products Co., Riviera Beach, Fla. (B, C)
Springfield Fabricators, Inc., Springfield, N. J. (B, C)
Sun Steel Co., Chicago 36, Ill. (A, B)
Syracuse Plastic Molders, Syracuse 2, N. Y. (B)
Technigraph, Winona, Minn. (A, B, C)
Therm-O-Form Plastics Co., Homewood, Ill. (A)
Things, Inc., Denver 3, Colo. (A, B, C)
Thomas, Charles W., Inc., Philadelphia 24, Pa. (A, B, C)
Timely Products Co., Des Moines 15, Iowa (B)
Topflight Corp., York, Pa. (A)
Tri-State Plastic Molding Co., Henderson, Ky. (C)
Usines Gheysen, S.A., Lembecq-Hal, Belgium (A, B)
Velveray Corp., New York 1, N. Y. (A)
Virginia Plak Co., New York 16, N. Y. (A, B)
Vogel Mfg. Co., The, Bridgeport 1, Conn. (C)
Wellington Print Works, Inc., Trenton, N. J. (A)
Wessel & Co., Stanley, Chicago 11, Ill. (B)
Willson Camera Co., Havertown, Pa. (A, B)

PULVERIZING

Bamberger, Claude P., Inc., Ridgefield Park, N. J.
Blum, Paul, Co., Buffalo 10, N. Y.
Collins, Caldwell & Dague, Inc., Paramount, Calif.
Composition Materials Co., Inc., New York 36, N. Y.
Coz Chemical Corp., Northbridge, Mass.
Danberg Chemical Co., Wallingford, Conn.
★Davies Nitrate Co., Inc., New York 6, N. Y.
Erie Plastics Co., Erie, Pa.
★Holland Co., M., Chicago, Ill.
Kaufman Glass Co., Plastics Div., Wilmington 99, Del.
Liquid Nitrogen Processing Corp., Chester, Pa.
Metals Disintegrating Co., Inc., Elizabeth B, N. J.
★Reed Plastics Corp., Worcester 8, Mass.
Ross & Son Co., Charles, Brooklyn 5, N. Y.
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y.
★Schulman, A., Inc., Akron, Ohio
Shuman, Philip, & Sons, Buffalo 6, N. Y.
★Standard-Union Fibre Co., Philadelphia 34, Pa.
Success Plastics Corp., Indianapolis 6, Ind.
★Woloch, George, Co., Inc., New York 11, N. Y.

RECLAIMERS, PLASTIC MATERIALS

Adell Plastics, Inc., Baltimore 15, Md.
Alpha Chemical & Plastics Corp., Newark 5, N. J.
Amco Plastic Materials, Inc., Brooklyn, 31, N. Y.
American Pyroxylin Corp., Kearny, N. J.
American Vinyl Corp., Maspeth 78, N. Y.
Bamberger, Claude P., Inc., Ridgefield Park, N. J.
Blum Co., Paul, Buffalo 10, N. Y.
Carver Corp., The, Norwood, Mass.
Collins, Caldwell & Dague, Inc., Paramount, Calif.
★Cooke Color & Chemical Co., Hackettstown, N. J.
Coz Chemical Corp., Northbridge, Mass.
★Davies Nitrate Co., Inc., New York 6, N. Y.
Eastern Plastic Materials, Slatersville, R. I.
Elton, Ted, N. White Plains, N. Y.
Erie Plastics Co., Erie, Pa.
Goren Co., H. L., Chicago 26, Ill.
★Holland Co., M., Chicago, Ill.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
★Interplastics Corp., New York 22, N. Y.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
L & P Tool Co., Cincinnati 25, Ohio
Liquid Nitrogen Processing Corp., Chester, Pa.
★Muehlstein, H., & Co., New York 17, N. Y.
Multiplastics, Wallingford, Conn.
Oppenheimer Corp., Buffalo 10, N. Y.
Plastic Materials, Inc., Hicksville, N. Y.
Plastic Molding Powders, Inc., Brooklyn 23, N. Y.
Plastic Scrap Materials, East Rochester, N. Y.
Plastics by Chapman, Richmond, Calif.
★Reed Plastics Corp., Worcester 8, Mass.
Rudd Plastic Fabrics Corp., Brooklyn 20, N. Y.
★Schulman, A., Inc., Akron, Ohio
Shuman, Philip, & Sons, Buffalo 6, N. Y.
Success Plastics Corp., Indianapolis 6, Ind.
★Superior Plastics, Inc., Chicago 12, Ill.
★Woloch, George, Co., Inc., New York 11, N. Y.
Yates Co., Erie, Pa.

RESIN PULP AND FIBRE PROCESSORS

Chicago Wood & Plastic Products, Chicago 41, Ill.
General Fibre Co., St. Louis, Mo.
Hawley Products Company, St. Charles, Illinois
Maine Molding Products, Boothbay Harbor, Maine

SILK SCREEN MAKERS

Aacon Industries, Inc., Brooklyn 24, N. Y.
Ambassador Arts, New York 11, N. Y.
Bolling Industries, Inc., Scranton 5, Pa.
Brimcar Mfg. Corp., New York 13, N. Y.
★Como Plastics, Inc., Columbus, Ind.

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★Conforming Matrix Corp., Toledo 2, Ohio
Electro Plastics Corp., Dallas 7, Texas
Formica Corp., The, Cincinnati 32, Ohio
General Machine & Tool Works, Walled Lake, Mich.
General Research & Supply Co., Grand Rapids 3, Mich.
Harva Co., Inc., The, Schoharie, N. Y.
Multicraft, Inc., Hillside, Ill.
Permanent Label Corp., Bloomfield, N. J.
Pyramid Screen Corp., Brookline 46, Mass.
Sampson Chemical & Pigment Corp., Chicago 12, Ill.
Sharpe Plastics, Inc., Sudbury, Mass.
★Sillcocks Miller Co., The, Maplewood, N. J.
Southern Plastic Products Co., Riviera Beach, Fla.
South Salem Studios, South Salem, N. Y.
Syracuse Plastic Molders, Syracuse 2, N. Y.
Technigraph, Winona, Minn.
Thomas, Charles W., Inc., Philadelphia 24, Pa.

SLITTING, CUTTING, SHEETING PLASTIC FILM

A.A.A. Plastic Co., New York 17, N. Y.
Aacon Industries, Inc., Brooklyn 24, N. Y.
Acme Laminating & Plastics Co., Inc., Detroit, Mich.
Allied Plastics Supply Corp., New York 38, N. Y.
Austin Industries, Inc., Marlboro, Mass.
Barr Corp., The, Richmond Hill, N. Y.
Blacher, B., New York 3, N. Y.
★Blank & Co., Inc., Arthur, Boston 15, Mass.
Brewster Enterprises, Inc., Rochester 9, N. Y.
Brockton Plastics, Inc., Brockton, Mass.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Coating Products, Inc., Englewood, N. J.
Columbia Slitting Co., Inc., New York 3, N. Y.
Crystal-X Corp., Lenni Mills, Pa.
★Davis Plastics Co., Joseph, Kearny, N. J.
Electro-Chemical Products, Cleveland 10, Ohio
Essex Plastic Machinery Co., Beverly, Mass.
Fassler & Co., Inc., M. J., Brooklyn 21, N. Y.
Fersons Industries, Inc., New York 1, N. Y.
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
G & S Label Corp., New York 1, N. Y.
Gomar Mfg. Co., Inc., Linden, N. J.
H & R Industries, Nazareth, Pa.
Jacobson Mfg. Co., S. I., Chicago 5, Ill.
Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
Kehr Products Co., Philadelphia 3, Pa.
Landers Corp., The, Toledo 1, Ohio
Maynard Plastics, Inc., Salem, Mass.
Metallic Plastics Corp., Long Island City 1, N. Y.
Monkley Corp., Worcester 8, Mass.
New England Tape Co., Hudson, Mass.
Pearson Industries, Long Island City 1, N. Y.
★Perforating Industries, Inc., Roselle Park, N. J.
Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
Plastic Laminating Corp., Vauxall, N. J.
★Plastic Stamping & Molding Corp., Chicago 47, Ill.
★Polymer Corp. of Pa., Reading, Pa.
★Polypenco, Inc., Reading, Pa.
Printon Corp., New York 10, N. Y.
Protective Lining Corp., Brooklyn 31, N. Y.
Reliance Plastic & Chemical Corp., Paterson 26, N. J.
Ridge Printing Co., Inc., Ridgefield, N. J.
Ross & Roberts, Inc., Stratford, Conn.
S-L-M Plastics, Avenel, N. J.
★Sandman Co., Eli, Worcester 9, Mass.
Sawaya Mfg. Co., Inc., Trinidad, Colo.
Shamban & Co., W. S., Culver City, Calif.
Teitelbaum Sons, Inc., N., New York 51, N. Y.
Thomas, Charles W., Inc., Philadelphia 24, Pa.
Wellington Print Works, Inc., Trenton, N. J.

TESTING LABORATORIES

Aerojet-General Corp., Structural Plastics Div., Azusa, Calif.
Axel Plastics Research Laboratories, Brooklyn 22, N. Y.
Bonwitt Labs., Dr. G. L., New York 23, N. Y.
Blaw-Knox Co., Pittsburgh 22, Pa.
Bostrom Corp., Milwaukee 4, Wis.
Branson Instruments, Inc., Stamford, Conn.
C.T.L., Inc., Cincinnati 15, Ohio
Colburn Laboratories, Inc., Chicago 5, Ill.
DeBell & Richardson, Inc., Hazardville, Conn.
Delsen Corporation, Glendale 4, Calif.
Desert Sunshine Exposure Tests, Phoenix, Ariz.
Froehling & Robertson, Inc., Richmond 6, Va.
★Furane Plastics, Inc., Los Angeles 39, Calif.
Gaynes Engineering Co., Chicago 12, Ill.
Gershen, Irvin J., Maplewood, N. J.
★Lawter Chemicals, Inc., Chicago 45, Ill.
Levey Laboratories, Harold A., New Orleans 18, La.
Lukens Laboratories, Inc., Newton, Mass.
★Lupoline Automatic Polishing Equipment Corp., Bronx 70, N. Y.
Mesa Plastics Co., Los Angeles 25, Calif.
Naken, William, Los Angeles 19, Calif.
New England Laboratories, Inc., Ipswich, Mass.
Patzig Testing Laboratories, Des Moines 17, Iowa
Pelmor Laboratories, Inc., Newtown, Pa.
Pitman Plastic Products, Inc., Pitman, N. J.
Plas-Tech Equipment Corp., Waltham 54, Mass.
★Reed Plastics Corp., Worcester 8, Mass.
Rhodes, Philip, H., & Associates, Cincinnati 25, Ohio
Skinner & Sherman Co., Inc., Newton 58, Mass.
Sorel, Frederick, Consultant, Prospect Heights, Ill.
★South Florida Test Service, Inc., Miami 44, Fla.
Steckler Labs., R., Cleveland 28, Ohio
Stringfield, Raymond B., Los Angeles 4, Calif.
Success Plastics Corp., Indianapolis 6, Ind.
Technical Research Institute, Pasadena, Calif.
Tracerlab, Inc., Waltham 54, Mass.

WELDING PLASTICS

A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
Alvimar Mfg. Co., Inc., New York 35, N. Y.
American Agile Corp., Bedford, Ohio
Aquador Plastics, Inc., Brooklyn 32, N. Y.
Art Plastics Mfg. Co., Los Angeles 21, Calif.
Atlas Mineral Products Co., Mertztown, Pa.
Barr Corp., The, Richmond Hill, N. Y.
Bel-Art Products, Pequannock, N. J.
Borkland Manufacturing Co., Marion, Ind.
Crystal-X Corp., Lenni Mills, Pa.
Curbell, Inc., Buffalo 7, N. Y.
★D & R Plastic Welders, Inc., Hazardville, Conn.
Electro-Chemical Products, Cleveland 10, Ohio
Fabrico Mfg. Corp., Chicago 22, Ill.
Fabri-Form Co., The, Byesville, Ohio
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
Heil Process Equipment Corp., Cleveland 11, Ohio
Industrial Plastic Fabricators, Norwood, Mass.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Kaykor Industries, Inc., Yardville, N. J.
Laramy Products Co., Hingham, Mass.
★Mayflower Electronic Devices, Inc., Little Ferry, N. J.
Maynard Plastics, Inc., Salem, Mass.
Mitchell's Plastic Studio, L. D., Pittsburgh 12, Pa.
Munray Products Div., The Fanner Mfg. Co., Cleveland 35, Ohio
Nalge Co., The, Rochester 2, N. Y.
Plasticles Corp., Detroit 27, Mich.
Plastic Suppliers and Manufacturers, Baton Rouge, La.
★Possis Machine Corp., Minneapolis 3, Minn.
Premier Plastics Co., Milwaukee 4, Wis.
Protective Lining Corp., Brooklyn 31, N. Y.
Rainbow Plastic Products, Inc., Minneapolis 16, Minn.
★Seelye Craftsmen, Minneapolis 13, Minn.
Spartan Products Co., Los Angeles 63, Calif.
Ultra Plastics, Inc., Philadelphia 30, Pa.
Usines Gheysen, S.A., Lembecq-Hal, Belgium

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American-British Chemical Supplies, Inc., New York 16, N. Y.
American Pyroxylin Corp., Kearny, N. J.
American Reinforced Plastics Co., Los Angeles 27, Calif.
Amsco Solvents & Chemicals Co., Cincinnati 29, Ohio
Architectural Plastics Corp., Eugene, Ore.
Atlas Plastics, Inc., Buffalo 10, N. Y.
Bamberger, Claude P., Inc., Ridgefield Park, N. J.
Berton Plastics, Inc., New York 3, N. Y.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Central Solvents & Chemicals Co., Chicago 12, Ill.
Chemicals & Pigments Corp., Newton 58, Mass.
Cordo Molding Products, Inc., New York 17, N. Y.
Crown Aerosol Products Co., Hollis 23, N. Y.
Crystal-X Corp., Lenni Mills, Pa.
★Davies Nitrate Co., Inc., N. Y. 6, N. Y.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
Elton, Ted, N. White Plains, N. Y.
Fisher Scientific Co., Pittsburgh 19, Pa.
Gem City Trading Corp., Dayton 1, Ohio
General Machine & Tool Works, Walled Lake, Mich.
Goren Co., H. L., Chicago 26, Ill.
Great Lake Solvents, Chicago, Ill.
Greene Plastics Corp., Hope Valley, R. I.
★Harwick Standard Chemical Co., Akron 5, Ohio
Henriques, J. B., Inc., N. Y., N. Y.
Hewitt, C. B., & Bros., Inc., N. Y., N. Y.
Industrial Plastic Coating Corp., Clifton, N. J.
Industrial Plastic & Equipment Co., Elizabeth, N. J.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Industrial Plastics, Ltd., London W.1, England
★Interplastics Corp., New York 22, N. Y.
Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
Kish DeLorme Eastern Resin Sales, Inc., Leonardo, N. J.
Knight Fiberglass & Chemicals, Inc., Chicago 18, Ill.
Kreidl Chemico Physical Co., The, New York 21, N. Y.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
Leon Chemical Industries, Inc., Warren, Mich.
Livingstone Coating Corp., Charlotte 8, N. C.
Magnolia Plastics, Inc., Chamblee, Ga.
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y.
Mitchell's L. D., Plastic Studio, Pittsburgh 12, Pa.
Modern Plastics, Miami 42, Fla.
Naftone, Inc., New York 22, N. Y.
Northwest Plastics Industries, Inc., Seattle 22, Wash.
★Omni Products Corp., New York 16, N. Y.
Oppenheimer Corp., Buffalo 10, N. Y.
Pioneer Lacquer Corp., Cherry Valley, Mass.
Plastic Engineering Co. of Tulsa, Tulsa, Okla.
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
Portz Plastics & Fibre Co., Milwaukee 3, Wis.
Poser, J., & Co., New York 1, N. Y.
Ram Chemicals, Inc., Gardena, Calif.
Rawsan Corp., Hialeah, Fla.
★Reed Plastics Corp., Worcester 8, Mass.
Riverdale Plastics & Chemical Corp., Culver City, Calif.
Rotobond Co., Bound Brook, N. J.
Shuman, Philip, & Sons, Buffalo 6, N. Y.
Smooth-On Mfg. Co., Jersey City 4, N. J.
Success Plastics Corp., Indianapolis 6, Ind.
Technicraft Co., Boston 34, Mass.
Thalco, Los Angeles 22, Calif.
United Laboratories Co., Linden, N. J.
United Sales Service, Los Angeles 35, Calif.
Vitex Plastics, New York 3, N. Y.
Von Opel, Georg, Corp., New York 5, N. Y.
Wams Co., The, Baltimore 2, Md.
Western Solvents & Chemicals Co., Detroit 11, Mich.
★Woloch, George, Co., Inc., New York 11, N. Y.

DISTRIBUTORS OF FOAMED PLASTICS AND FOAMING AGENTS

Architectural Plastics Corp., Eugene, Ore.
Crystal-X Corp., Lenni Mills, Pa.
Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
Fabri-Kal Corp., Kalamazoo, Mich.
General Foam Corp., New York 31, N. Y.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
Kish DeLorme Eastern Resin Sales, Inc., Leonardo, N. J.
Knight Fiberglass & Chemicals, Inc., Chicago 18, Ill.
Kreidl Chemico Physical Co., The, New York 21, N. Y.
Naftone, Inc., New York 22, N. Y.
Oppenheimer Corp., Buffalo 10, N. Y.
Plastic Engineering Co. of Tulsa, Tulsa, Okla.
Plastics by Chapman, Richmond, Calif.
Ram Chemicals, Inc., Gardena, Calif.
Thombert, Inc., Newton, Iowa
United Sales Service, Los Angeles 35, Calif.

DISTRIBUTORS OF CHEMICALS AND ADDITIVES

Aceto Chemical Co., Inc., Flushing, N. Y.
★Ackerman Gould Co., Oceanside, N. Y.
American-British Chemical Supplies, Inc., New York 16, N. Y.
American Resin Corp., Chicago 13, Ill.
Amsco Solvents & Chemicals Co., Cincinnati 29, Ohio
Architectural Plastics Corp., Eugene, Ore.
Barker-Davis Machine Co., Inc., Leominster, Mass.
Berkshire Chemicals, Inc., New York 17, N. Y.
Berton Plastics, Inc., New York 3, N. Y.
Buffalo Solvents & Chemicals Corp., Buffalo 7, N. Y.
Central Solvents & Chemicals Co., Chicago 12, Ill.
Chemicals & Pigments Corp., Newton 58, Mass.
Crown Aerosol Products Co., Hollis 23, N. Y.
Danson, Barnett J., & Associates, Ltd., Toronto 12, Ont., Canada
★Davies Nitrate Co., Inc., New York 6, N. Y.
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
Great Lakes Solvents, Inc., Chicago 47, Ill.
Hoosier Solvents & Chemicals Corp., Indianapolis 22, Ind.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
International Eastern Co., N. Y., N. Y.
★Kassel Export Co., Englewood, N. J.
Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
Kish DeLorme Eastern Resin Sales, Inc., Leonardo, N. J.
Knight Fiberglass & Chemicals, Inc., Chicago 18, Ill.
★Krieger Color & Chemical Co., Inc., Hollywood 38, Calif.
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y.
Naftone, Inc., New York 22, N. Y.
★Omni Products Corp., New York 16, N. Y.
Osborn Co., C. J., Linden, N. J.
Pioneer Lacquer Corp., Cherry Valley, Mass.
Plastic Engineering Co. of Tulsa, Tulsa, Okla.
★Plastic Molders Supply Co., Inc., Fanwood, N. J.
Plastics by Chapman, Richmond, Calif.
Ram Chemicals, Inc., Gardena, Calif.
★Reed Plastics Corp., Worcester 8, Mass.
Riverdale Plastics & Chemical Corp., Culver City, Calif.
Sanitized Sales Co. of America, Inc., New York 16, N. Y.
Smith Chemical & Color Co., Inc., Brooklyn 1, N. Y.
Southern Solvents & Chemicals Corp., New Orleans 21, La.
Superior Materials, Inc., N. Y., N. Y.
Teitelbaum, N., Sons, Inc., New York 51, N. Y.
United Sales Service, Los Angeles 35, Calif.
★United States Gypsum Co., Chicago 6, Ill.
United Ultramarine & Chemical Co., Inc., New York 6, N. Y.
Western Solvents & Chemicals Co., Detroit 11, Mich.
★Whittaker, Clark, & Daniels, Inc., New York 7, N. Y.
Wolverine Solvents & Chemicals Co., Grand Rapids 8, Mich.

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DISTRIBUTORS OF FILM, SHEETING, AND SHAPES

- A & B Plastics, Div. of Plastic Supply Corp., Seattle 9, Wash.
- Airmate Co., Toledo 13, Ohio
- Allied Plastics Supply Corp., New York 38, N. Y.
- Almac Plastics, Inc., New York 12, N. Y.
- American Pyroxylin Corp., Kearny, N. J.
- Architectural Plastics Corp., Eugene, Ore.
- Argo Plastic Products Co., Cleveland 13, Ohio
- Aristocrat Plastics, Inc., Newark 3, N. J.
- ★Auburn Plastic Engineering, Chicago 9, Ill.
- Austin Industries, Inc., Marlboro, Mass.
- ★Barron, J. E., Plastics, Inc., Cincinnati 2, Ohio
- Bel-Art Products, Pequannouk, N. J.
- Berton Plastics, Inc., New York 3, N. Y.
- ★Blank, Arthur, & Co., Inc., Boston 15, Mass.
- Blossom Mfg. Co., Inc., Brooklyn 23, N. Y.
- Brandywine Fibre Products Co., Wilmington, Del.
- Byers, A. M., Co., Pittsburgh 22, Pa.
- ★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
- ★Carroll, J. B., Co., Chicago 12, Ill.
- Chambers, S. L., Associates, New York 36, N. Y.
- ★Colonial Kolonite Co., Chicago 47, Ill.
- ★Commercial Plastics & Supply Corp., New York 12, N. Y.
- Consolidated Plastics & Mfg. Co., Chicago 10, Ill.
- Crystal-X Corp., Lenni Mills, Pa.
- Curbell, Inc., Buffalo 7, N. Y.
- Delta Products, Div. of Air Accessories, Inc., Fort Worth, Texas
- Dumais, Joseph F., Co., Fall River, Mass.
- Dura-Lee Corp., Kansas City 5, Mo.
- Dura Plastics of New York, Inc., New York 16, N. Y.
- Efka Plastic Corp., Hoboken, N. J.
- Electro-Chemical Products, Cleveland 10, Ohio
- Electro Plastics Corp., Dallas 7, Texas
- ★Engineered Plastics, Inc., Gibsonville, N. C.
- Erie Plastics Co., Erie, Pa.
- Evans-Zeier Plastic Co., Madison 4, Wis.
- Fabri-Kal Corp., Kalamazoo, Mich.
- Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
- General Foam Corp., New York 31, N. Y.
- General Machine & Tool Works, Walled Lake, Mich.
- Harva Co., The, Inc., Schoharie, N. Y.
- Hastings Plastics, Inc., Santa Monica, Calif.
- Helmac Plastics, Inc., Pinellas Park, Fla.
- Henriques, J. B., Inc., New York 21, N. Y.
- Hermes Plastics, Inc., New York 14, N. Y.
- Industrial Plastic Coating Corp., Clifton, N. J.
- Industrial Plastic & Equipment Co., Elizabeth, N. J.
- Industrial Plastic Fabricators, Norwood, Mass.
- Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
- Insulating Fabricators of New England, Inc., Watertown 72, Mass.
- Jacobson, S. I., Mfg. Co., Chicago 5, Ill.
- Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
- Kingsbacher Murphy Co., Los Angeles 45, Calif.
- ★Kleinewefers, Joh., Söhne, Krefeld, West Germany
- Laminated Sheet Products Corp., Norwood, Mass.
- Livingstone Coating Corp., Charlotte 8, N. C.
- Long, Thomas J., Carle Place, N. Y.
- Lustra-Cite Industries, Inc., Brooklyn 11, N. Y.
- Malco Plastics, Inc., Baltimore 15, Md.
- Mitchell's L. D., Plastic Studio, Pittsburgh 12, Pa.
- Modern Plastics, Miami 42, Fla.
- Naftone, Inc., New York 22, N. Y.
- Norman Plastics, Inc., New York 3, N. Y.
- Northwest Plastics Industries, Inc., Seattle 22, Wash.
- ★Omni Products Corp., New York 16, N. Y.
- P-V-A Industries, New York 18, N. Y.
- Plast-Ad Mfg. Co., South Bend, Ind.
- Plastic Center, Rochester 4, N. Y.
- Plastic-Craft Products Corp., West Nyack, N. Y.
- Plastic Engineering Co. of Tulsa, Tulsa, Okla.
- Plastic Engineering & Sales Corp., Fort Worth, Texas
- Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur, Ga.
- ★Plastic Stamping & Molding Corp., Chicago 47, Ill.
- Plastic Suppliers & Manufacturers, Baton Rouge, La.
- Plasticles Corp., Detroit 27, Mich.
- Plastics by Chapman, Richmond, Calif.
- Plastics Center of Texas, San Antonio 4, Texas
- Plastics, Inc., St. Paul 5, Minn.
- Plastics Industries, Inc., Athens, Tenn.
- Polo Plastics, Co., Milwaukee 12, Wis.
- Portz Plastics & Fibre Co., Milwaukee 3, Wis.
- Poser, J., & Co., New York 1, N. Y.
- Printon Corp., New York 10, N. Y.
- Raven Industries, Inc., Sioux Falls, S. D.
- Rayll Plastics Co., Brooklyn 6, N. Y.
- Rhodia, Inc., New York 22, N. Y.
- ★Robeco Chemicals, Inc., New York 10, N. Y.
- Rotobond Co., Bound Brook, N. J.
- Ryerson, Jos. T., & Son, Inc., Chicago, Ill.
- Singleton & Mack, Inc., Akron 13, Ohio
- Sommers Plastic Products Co., East Rutherford, N. J.
- Success Plastics Corp., Indianapolis 6, Ind.
- Teitelbaum, N. Sons, Inc., New York 51, N. Y.
- Thombert, Inc., Newton, Iowa
- ★Transilwrap Co., Chicago 40, Ill.
- Transplastics Fabricating Co., Boston 15, Mass.
- United Sales Service, Los Angeles 35, Calif.
- Velveray Corp., New York 1, N. Y.
- Vitex Plastics, New York 3, N. Y.
- Von Opel, Georg, Corp., New York 5, N. Y.
- Weiss & Klau, New York 13, N. Y.
- Wyatt's Plastics, Inc., Houston 1, Texas

DISTRIBUTORS OF FABRICS, PAPERS, FILLERS, AND REINFORCEMENTS

- Allied Plastics Supply Corp., New York 38, N. Y.
- American Reinforced Plastics Co., Los Angeles 27, Calif.
- Architectural Plastics Corp., Eugene, Ore.
- Berkshire Chemicals, Inc., New York 17, N. Y.
- Berton Plastics, Inc., New York 3, N. Y.
- ★Chemical Development Corp., Danvers, Mass.
- Chemicals Pigments Corp., Newton 58, Mass.
- Cordo Molding Products, Inc., New York 17, N. Y.
- Crystal-X Corp., Lenni Mills, Pa.
- Doggett, Stanley, Inc., New York 13, N. Y.
- Erie Plastics Co., Erie, Pa.
- Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
- General Machine & Tool Works, Walled Lake, Mich.
- Great Lakes Solvents, Inc., Chicago 47, Ill.
- Griffin, Campbell, Hayes, Walsh, Inc., New York 10, N. Y.
- Hoosier Solvents & Chemicals Corp., Indianapolis 22, Ind.
- Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
- Kish DeLorme Eastern Resin Sales, Inc., Leonardo, N. J.
- Knight Fiberglass & Chemicals, Inc., Chicago 18, Ill.
- Landers Corp., The, Toledo 1, Ohio
- Landers-Segal Color Co., Brooklyn 31, N. Y.
- Leon Chemical Industries, Inc., Warren, Mich.
- Mineralite Sales Corp., Mineola, N. Y.
- Norman Plastics, Inc., New York 3, N. Y.
- ★Omni Products Corp., New York 16, N. Y.
- Oppenheimer Corp., Buffalo 10, N. Y.
- Osborn, C. J., Co., Linden, N. J.
- Plastic Engineering Co. of Tulsa, Tulsa, Okla.
- Plastics, Inc., St. Paul 5, Minn.
- Pluess-Staufer (North American), Inc., New York 5, N. Y.
- Portz Plastics & Fibre Co., Milwaukee 3, Wis.
- Printon Corp., New York 10, N. Y.
- Singleton & Mack, Inc., Akron 13, Ohio
- Smith Chemical & Color Co., Inc., Brooklyn 1, N. Y.
- Sommers Plastic Products Co., East Rutherford, N. J.
- Success Plastics Corp., Indianapolis 6, Ind.
- Superior Materials, Inc., New York 6, N. Y.
- Thalco, Los Angeles 22, Calif.
- United Sales Service, Los Angeles 35, Calif.
- ★United States Gypsum Co., Chicago 6, Ill.
- United Ultramarine & Chemical Co., Inc., New York 6, N. Y.
- Von Opel, Georg, Corp., New York 5, N. Y.
- Wagner, Charles A., Co., Inc., Philadelphia 40, Pa.

DISTRIBUTORS OF LAMINATES AND REINFORCED PLASTICS

- Allied Plastics Supply Corp., New York 38, N. Y.
- Architectural Plastics Corp., Eugene, Ore.
- Brandywine Fibre Products Co., Wilmington, Del.
- ★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
- ★Colonial Kolonite Co., Chicago 47, Ill.
- ★Commercial Plastics & Supply Corp., New York 12, N. Y.
- Cordo Molding Products, Inc., New York 17, N. Y.
- Curbell, Inc., Buffalo 7, N. Y.
- ★Engineered Plastics, Inc., Gibsonville, N. C.
- General Machine & Tool Works, Walled Lake, Mich.

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Harva Co., Inc., The, Schoharie, N. Y.
Hermes Plastics, Inc., New York 14, N. Y.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Insulating Fabricators of New England, Inc., Watertown 72, Mass.
Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
Kish DeLorme Eastern Resin Sales, Inc., Leonardo, N. J.
Knight Fiberglass & Chemicals, Inc., Chicago 18, Ill.
Laminated Sheet Products Corp., Norwood, Mass.
Long, Thomas J., Inc., Carle Place, N. Y.
★Mico Instrument Co., Cambridge 38, Mass.
Mitchell's, L. D., Plastic Studio, Pittsburgh 12, Pa.
Modern Plastics, Miami 42, Fla.
Plastic-Craft Products Corp., W. Nyack, N. Y.
Plastic Engineering & Sales Corp., Fort Worth, Texas
Plastics Center of Texas, San Antonio 4, Texas
Portz Plastics & Fibre Co., Milwaukee 3, Wis.
Ryerson, Jos. T., & Son, Inc., Chicago, Ill.
Teitelbaum, N., Sons, Inc., New York 51 N. Y.
Thombert, Inc., Newton, Iowa
United Sales Service, Los Angeles 35, Calif.
Vitex Plastics, New York 3, N. Y.
Von Opel, Georg, Corp., New York 5, N. Y.

DISTRIBUTORS OF MACHINERY AND EQUIPMENT

Aaron Machinery Co., New York 12, N. Y.
★Acme Machinery & Mfg. Co., Inc., Yonkers, N. Y.
Alpine American Corp., Saxonville, Mass.
Austin Industries, Inc., Marlboro, Mass.
Baco Co., New York 13, N. Y.
Barclay Industries Inc., New York, N. Y.
Bonwitt, Eric, Chicago 5, Ill.
★Brosites Machine Co., Inc., New York 7, N. Y.
Caig Cosmopolitan, New York 17, N. Y.
★Callanan, J. A., Co., Chicago 6, Ill.
Cerro de Pasco Sales Corp., New York 22, N. Y.
Cosa Corp., New York 17, N. Y.
★Covema s.r.l., Milan, Italy
Crystal-X Corp., Lenni Mills, Pa.
Danson, Barnett J., & Associates, Ltd., Toronto 12, Ont., Canada.
Electric Trading Co., New York 13, N. Y.
Electro-Tech Equipment Co., New York 13, N. Y.
Essex Plastic Machinery Co., Beverly, Mass.
★Gane Bros. & Lane, Inc., Chicago 7, Ill.
General Foam Corp., New York 31, N. Y.
Hale & Kullgren, Inc., Akron, Ohio
★Hochman Plastics Machinery Corp., Newark 2, N. J.
Industrial Plastic Fabricators, Norwood, Mass.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
Industrial Plastics, Ltd., London W.1, England
International Eastern Co., New York 1, N. Y.
International Vulcanizing Corp., Boston 15, Mass.
★Johnson Machinery Co., Newark, N. J.
Kautex-U. S. Sales Co., Inc., Flushing 54, N. Y.
Kingsbacher Murphy Co., Los Angeles 45, Calif.
Kleen-Stik Products, Inc., Chicago 31, Ill.
Laramy Products Co., Hingham, Mass.
Leedpak, Inc., New York 1, N. Y.
★Lester Engineering Co., Cleveland 13, Ohio
MacMillin Hydraulic Engineering Corp., Skokie, Ill.
Malco Plastics, Inc., Baltimore 15, Md.
Maplewood Cos., Livingston, N. J.
Miag North America, Inc., Minneapolis 4, Minn.
★Mico Instrument Co., Cambridge 38, Mass.
Mobay Chemical Co., Pittsburgh 34, Pa.
Moldex, Yonkers, N. Y.
★Omni Products Corp., New York, N. Y.
Pace Co., F. C., Grand Rapids, Mich.
Patron Transmission Co., Inc., New York 13, N. Y.
Plastic Machinery Exchange, Boonton, N. J.
Plastic Molders Supply Co., Inc., Fanwood, N. J.
Plastic Suppliers and Mfrs., Baton Rouge, La.
Poser & Co., J., New York 1, N. Y.
★Rainville Co., Inc., The, Garden City, N. Y.
Rapp Foreign Trade Corp., N. Y., N. Y.
Ringler-Dorin, Inc., New York, N. Y.
Ryerson, Jos. T., & Son, Inc., Chicago, Ill.
★Seelye Craftsmen, Minneapolis 13, Minn.
Specialty Products Co., Jersey City 2, N. J.
★Standard Tool Co., Leominster, Mass.
Stein Equipment Co., Brooklyn 15, N. Y.
Superior Materials, New York 6, N. Y.
Swift, M., & Sons, Inc., Hartford 1, Conn.
★Symons, Ralph B., Associates, Inc., Tiverton, R. I.
Technical Product Co., New York 17, N. Y.
United Laboratories Co., Linden, N. J.
United Sales Service, Los Angeles 35, Calif.
West Coast Plastics Distributors, Inc., Culver City, Calif.

DISTRIBUTORS OF INSTRUMENTS

Atkins Technical, Inc., Cleveland 13, Ohio
Caig Cosmopolitan, N. Y. 17, N. Y.
Electro-Tech Equipment Co., New York 13, N. Y.
Hudson Automatic Machine & Tool Co., Union City, N. J.
Plaster Supply House, Chicago 90, Ill.
★Rainville Co., Inc., The, Garden City, N. Y.
Rapp Foreign Trade Corp., New York 6, N. Y.

DISTRIBUTORS OF MACHINE TOOLS

Aaron Machinery Co., New York 12, N. Y.
Cosa Corp., New York 17, N. Y.
★DoAll Co., The, Des Plaines, Ill.
★Hochman Plastics Machinery Corp., Newark 2, N. J.
Hudson Automatic Machine & Tool Co., Union City, N. J.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
Moldex, Yonkers, N. Y.
Ryerson, Jos. T., & Son, Chicago, Ill.
Sherman Rubber Co., Div. of Botwinik Bros., Inc., Worcester, Mass.
United Sales Service, Los Angeles 35, Calif.

DISTRIBUTORS OF SUPPLIES

★Ackerman Gould Co., Oceanside, N. Y.
Allied Plastics Supply Corp., New York 38, N. Y.
Barclay Industries Inc., N. Y., N. Y.
Barker-Davis Machine Co., Inc., Leominster, Mass.
Berton Plastics, New York 3, N. Y.
Brandywine Fibre Products Co., Wilmington, Del.
Brown Aerosol Products Co., Hollis 23, N. Y.
★Cadillac Plastic & Chemical Co., Detroit 3, Mich.
Caig Cosmopolitan, New York 17, N. Y.
★Callanan, J. A., Co., Chicago 6, Ill.
★Colonial Kolonite Co., Chicago 47, Ill.
Danson, Barnett J., & Associates, Ltd., Toronto 12, Ontario, Canada
Eisler Engineering Co., Inc., Newark 3, N. J.
Electro-Chemical Products, Cleveland 10, Ohio
Franklin Fibre-Lamitex Corp., Wilmington 99, Del.
★Gane Bros. & Lane, Inc., Chicago 7, Ill.
Gerin Mfg. Co., Inc., Newark 7, N. J.
Great Lakes Solvents, Chicago 47, Ill.
Hart, William A., & Associates, St. Charles, Ill.
★Harwick Standard Chemical Co., Akron 5, Ohio
Hewitt, C. B., & Bros., Inc., New York 13, N. Y.
★Hochman Plastics Machinery Corp., Newark 2, N. J.
Industrial Marking Equipment Co., Inc., Brooklyn 8, N. Y.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., W. Hartford 10, Conn.
International Eastern Co., N. Y., N. Y.
★Kassel Export Co., Englewood, N. J.
Kaufman Glass Co., Plastic Div., Wilmington 99, Del.
★Kleinewefers, Joh., Söhne, Krefeld, West Germany
Knight Fiberglass & Chemicals, Inc., Chicago 18, Ill.
Laramy Products Co., Hingham, Mass.
Leon Chemical Industries, Inc., Warren, Mich.
★McKesson & Robbins, Inc., Chemical Dept., New York 17, N. Y.
★Mico Instrument Co., Cambridge 38, Mass.
★NRC Equipment Corp., Newton 61, Mass.
Naftone, Inc., New York 22, N. Y.
★Omni Products Corp., New York 16, N. Y.
Patron Transmission Co., Inc., New York 13, N. Y.
Pelmor Labs., Inc., Newtown, Pa.
Plaster Supply House, Chicago 90, Ill.
Plastic Suppliers and Mfrs., Baton Rouge, La.
Plastics Center of Texas, San Antonio 4, Texas
★Rainville Co., Inc., The, Garden City, N. Y.
Ram Chemicals, Inc., Gardena, Calif.
Sommer & Maca Glass Machinery Co., Chicago 50, Ill.
★Standard Tool Co., Leominster, Mass.
Teitelbaum, N., Sons, Inc., New York 51, N. Y.
★Thoreson-McCosh, Inc., Detroit 19, Mich.
Trimpe, The, L. H., Co., Los Angeles 32, Calif.
United Sales Service, Los Angeles 35, Calif.
★Whittaker, Clark, & Daniels, Inc., New York 7, N. Y.

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Converters and Processors

The following personnel and equipment directories are designed to be as complete as possible on the basis of available information submitted by the companies themselves. Listings are alphabetical and geographical, by state.

CUSTOM MOLDERS AND EXTRUDERS

C—Compression; E—Extrusion; I—Injection; T—Transfer; CM—Cold Molding

ALABAMA

Alabaster Plastics Corp., Alabaster (I)
Injection machines: 2–4 oz.; 1–8 oz.; 1–12 oz.
Vice Pres., Sls. Mgr., Pur.Agt.-Thomas M. Pearce

***Decatur Plastic, Inc.,** Decatur (I)
Injection machines: 4–3 oz.; 1–10 to 16 oz.; 2–12 to 16 oz.
Pres., Sls. Mgr. & Pur. Agt.—M. E. Hickson
Vice Pres.—J. Williams

CALIFORNIA

***aaRBee Plastic Co.,** Inglewood (I)
Injection machines: 10–2 to 24 oz.
Pres.—R. B. Gutsch
Plant Supt.—Eugene Gabelhouse

Aerojet-General Corp., Structural Plastics Div., Azusa (C)
Compression presses: 1–20 ton; 1–35 ton; 1–45 ton; 2–50 ton; 1–200 ton; 2–240 ton; 1–680 ton; 1–1000 ton
Pres.—D. A. Kimball
Vice Pres.—Div. Mgr.—E. L. Rucks
Co. Mgr., Customer Relations—W. L. Gore
Div. Mgr., Customer Relations—J. F. Weschler
Pur. Agt.—L. Pell

***Airconductors,** Gardena (CM)
Personnel: see p. 1181

***All-Power Mfg. Co.,** Montebello (I)
Injection machines: 1–12 oz.; 1–16 oz.; 1–22 oz.
Pres.—M. E. Danielson
Vice Pres., Gen. Mgr.—S. R. Alger
Sls. Mgr.—R. W. Burnham

***Alladin Plastics, Inc.,** Gardena (I)
Injection machines: 15: 1–3 oz.; 3–8 oz.; 3–10 oz.; 3–16 oz.; 4–28 oz.; 1–100 oz.
Pres.—Sam Avedon
Vice Pres., Sls. Mgr.—Harvey Avedon
Pur. Agt.—Robert Wuchner

***Allied Engineering & Production Corp.,** Alameda (C, E, I)
Compression presses: 9–50 to 200 tons
Extrusion machines: 1
Injection machines: 2-2½ oz.
Pres.—H. E. Miller, Jr.
Vice Pres.—L. E. Miller
Sls. Mgr.—A. A. Miller
Pur. Agt.—R. E. Heacock

***Almac Mfg. Co.,** El Monte (I, T)
Injection machines: 2–16 oz.; 1–12 oz.; 1–4 oz.
Transfer presses: 1–300 ton; 2–150 ton; 3–60 ton
Partners: Herbert M. Langton, Alex J. Segesdy

Automatic Plastic Molding Co., Berkeley (C, I, T)
Compression presses: 8–85 ton to 200 ton
Injection machines: 3–4 oz. to 6 oz.; 2–12 to 16 oz.
Transfer presses: 2
Pres.—Forrest Engelhart
Vice Pres., Sls. Mgr.—A. J. Carlson
Pur. Agt.—R. S. Wallace

***Calresin Co., Div. of Knudsen Creamery,** Los Angeles (C)
Compression presses: 10 to 100 ton
Gen. Mgr.—Paxton Beale
Sls. Mgr.—Ed Hanke
Pur. Agt.—Fred Gregoire

Chemtrol, Lynwood (I)
Injection machines: 1 (Special Equipment)
Vice Pres., Gen Mgr.—Martin Usab
Vice Pres., Sales—Jack G. Fuller
Pur. Agt.—Claire Snow

***Chemtron Fiber Glass Co.,** El Monte (CM)
Personnel: see p. 1183

Couroc of Monterey, Monterey (C)
Commpression presses: 2-90 ton; 1–500 ton; 1–200 ton; 2–300 ton
Pres.—Guthrie Courvoisier
Secy., Treas.—Walter T. Johnson

Crest Molded Products, Inc., Arcadia (C, I)
Compression and transfer presses: 2–40 ton; 2–80 ton; 2–100 ton; 4–100 ton; 6–200 ton; 2–300 ton; 2–350 ton
Pres.—Charles Martins
Vice Pres.—Stephen Civerolo
Gen. Mgr., Sls. Mgr.—Kenneth R. Mergen
Pur. Agt.—Ralph Hord

***Delkay Plastics Corp.,** Gardena (I)
Injection machines: 9–2 to 16 oz.
Pres. & Gen. Mgr.—Ed. Favre
Vice Pres. & Plant Sup't.—Robert E. Roper
Sls. Mgr. & Sec.—Wm. H. Roper
Pur. Agt. & Treas.—C. Richard Roper

★**Dumont Corp.,** San Rafael (C)
Compression presses: 2–60 ton; 2–200 ton; 1–400 ton; 1–650 ton
Pres.—R. M. Daiss
Vice Pres., Sls. Mgr.—W. B. Layton, Jr.
Pur. Agt.—J. Hirsch

Extruders, Inc., Hawthorne (E)
Extrusion machines: 2½"; 3½"; 4½"
Pres., Sls. Mgr.—W. B. Sander
Pur. Agt.—E. J. Hyde

***Fortin Plastics, Inc.,** Van Nuys (C, T)
Compression presses: 3–50 ton
Transfer presses: 1–50 ton
Pres.—Chester H. Fortin
General Manager—A. B. Ward.
Sls. Mgr.—George G. Luke
Works Manager—S. A. Wright

Gaylord Plastics, Inc., Santa Monica (C, T)
Compression presses: 5–from 10 to 85 ton
Transfer presses: 5–from 2 to 15 ton
Pres., Sls. Mgr.—G. W. Main
Vice Pres., Pur. Agt.—H. P. Glimberg

***General Plastics Corp.,** Los Angeles (C)
Compression presses: 4–25 ton; 2–40 ton; 1–100 ton; 2–250 ton
Pres.—Fausto M. Ricci
Vice Pres.—Joseph H. Kingsley
Sales Mgr.—Herbert H. Schwartz

***Gibbs Mfg.,** Berkeley (C, I)
Compression presses: 10–20 ton to 300 ton
Injection machines: 2–4 oz. to 6 oz.; 1–12 oz.
Pres.—James Gibbs
Vice Pres.—M. Gibbs Allacher
Sales Rep.—Bob Leitch
Pur. Agt.—J. F. Allacher

***Jet Specialties Co.,** Los Angeles (E, I)
Extrusion machines: 8–1½" to 4½"
Injection machines: 5–2 oz. to 16 oz.
Pres.—Lloyd W. Johnson
Vice Pres. & Sls. Mgr.—Gerald H. Johnson
Vice Pres. & Pur. Agt.—Malcolm S. Haywood

Kennerley-Spratling, Inc., Berkeley (C, I, T)
Compression presses: 50 to 100 ton
Injection machines: 1–16 oz.
Transfer presses: 50 to 100 ton
Pres.—Fred L. Kennerley
Vice-Pres.—J. H. Murphy
Secy. & V. P.—Ernest N. Spratling
Treas.—R. W. Garrett

Kimball Manufacturing Corp., San Rafael (C)
Compression presses: 10–from 20 ton to 300 ton, 10" x 10" platen to 4' x 8' platen
Pres., Custom Sls. Mgr.—William R. Kimball
Vice Pres., Pur. Agt.—G. R. Mallory
Sls. Mgr. (Proprietary)—Jack Lang

***Kraloy Plastic Pipe Co., Inc.,** Los Angeles (E)
Extrusion machines: 2–2½"; 2–3½"; 1–4½"
Pres.—Chester W. Anderson
Exec. Vice Pres.—Victor J. Haydel
Vice Pres., Sls. Mgr.—Russell W. Johnson
Pur. Agt.—Beverly Priess

★**Krieger Color & Chemical Co., Inc.,** Hollywood (E, I)
Extrusion machines: 1–1½"
Injection machines: 1–2 oz.
Pres.—Michael Krieger
Vice Pres., Sls. Mgr.—Lawrence S. Krieger
Pur. Agt.—Lawrence E. Avidan

***Lee Deane Products, Inc.,** Santa Fe Springs (C, I, T)
Compression presses: 2–15 ton to 50 ton; 4–50 ton to 350 ton
Injection machines: 3–6 oz. to 22 oz.
Transfer presses: 14–50 ton to 350 ton
Pres. J. Linn Rodgers, III
Vice Pres.—Jennie P. Severance
Sls. Mgr.—Robert B. Caves
Pur. Agt.—Roger F. Conant

***Marken Plastic Corp.,** Los Angeles (E)
Extrusion machines: 2–2½"; 2–3½"

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* Operates own tool room
★ Indicates Advertiser

Pres.—Andrew M. Martin
Sls. Mgr., Pur. Agt.—Carl Anderson

Monrovia Plastic Co., Inc., Monrovia (I)
Injection machines: 1–4 oz.; 2–12 oz.

***Moore Mfg., Inc.,** San Francisco (E)
Extrusion machines: 6–from 1½" to 4½"
Pres.—John Max Moore
Exec. Vice Pres.—J. T. Moore
Pur. Agt.—F. Kelly

***Olympic Plastics Co., Inc.,** Los Angeles (C, I, T)
Compression presses: 20–50-to 1000 ton
Injection machines: 10–1–32 oz.
Transfer presses: 5 to 300 ton
Pres.—David Rome
Vice Pres.—D. C. Siteman
Sls. Mgr.—H. M. Rome
Pur. Agt.—J. Borack

***Peerless Plastics,** Culver City (C, I, T)
Compression presses: 1–500 ton; 1–350 ton; 1–150 ton; 2–50 ton; 1–15 ton
Injection machines: 2–1 oz.; 1–2½ oz.; 2–8 oz.; 1–12 oz.; 1–16 oz., 1–20/28 oz.; 1–48 oz.
Transfer presses: 1–350 ton; 1–150 ton; 2–50 ton
Pres. & Gen. Mgr.—Arthur Sugarman

***Plastic Age Sales, Inc.,** Saugus (C, T)
Compression Presses: 22–from 5 ton to 750 ton
Transfer Presses: 2–75 ton
Pres.—J. A. Kramer
Vice Pres.—Edward M. Commeford
Sls. Mgr.—H. E. Renner
Pur. Agt.—A. S. Kramer

***Plastic Model Engineering,** Van Nuys (I)
Injection Machines: 1–¾ oz.
Pres.—Edward F. Broeski
Secy.—Jane E. Broeski

Plastic Process Co., Div. of Monadnock Mills, Los Angeles (E)
Extrusion machines: 8–1 to 4½"
Pres.—E. E. Kotkin
Vice Pres.—H. R. Hedstrom
Sls. Mgr. & Vice Pres.—M. A. Crystal
Pur. Agt.—H. Hunton

Plastics, Inc., Pasadena (I)
Injection machines: 1–12-16 oz.; 1–8 oz.
Pres.—Burton T. Dake
Vice Pres.—S. Dake
Sls. Mgr.—James Hackney
Pur. Agt.—Mary Fisher

Plastron Specialties, Inc., Los Angeles (E)
Extrusion Machines: 1–1"; 3–2½"; 1–3½"
Pres.—Henry E. Kremers
Vice Pres., Pur. Agt.—E. L. Messerli
Sls. Mgr.—H. S. Stickney

Randazzo Plastic Co., Inc., Los Angeles (I)
Injection Machines: 5: 1–4 oz., 3–8 oz., 1–12 oz.
Pres.—Marion G. Randazzo
Secy., Treas.—Gus Rizzo

***Reinhold Engineering & Plastics Co.,** Norwalk (C, T)
Compression Presses: 12
Transfer Presses: 12
Pres.—J. P. Gruettner
Vice Pres.—H. Eckardt
Sls. Mgr.—M. Dagneau
Pur. Agt.—P. Hendrix

***Reinhold-Geiger Plastics, Inc.,** Los Angeles (C. I, T)
Compression Presses: 23–100 ton 300 ton
Injection Machines: 7–1 oz. to 3 oz.
Transfer Presses: 11–100 ton
Pres.—Lisle Reinhold
Vice Pres.—Harry Geiger

***Remler Co.,** San Francisco (C. I, T)
Compression Presses: 15–21 to to 350 ton
Injection Machines: 2–8 oz. to 16 oz.
Transfer Presses: 10–55 ton to 230 ton
Pres.—R. C. Gray
Sls. Mgr.—A. B. Hart
Plant Mgr.—Leonard L. Roberts
Pur. Agt.—Stanley E. Mohr

***Revell, Inc.,** Venice (I)
Injection Machines: 1–2½ oz., 2–4 to 6 oz., 2–8 oz., 7–12 to 16 oz.
Pres.—Lewis H. Glaser
Vice Pres.—Bernard G. Ramos
Sls. Mgr., Pur. Agt.—Sam Melcher

***Roger Mfg. Co.,** Oakland (C, I, T)
Compression Presses: 1–30 ton; 1–40 ton; 1–75 ton
Injection Machines: 1–1 oz.; 1–4 oz.; 1–8 oz.; 1–16 oz.
Transfer Press: 1–150 ton
Pres.—A. J. Roger

***Shamban, W. S., & Co.,** Culver City (C, E, I)
Pres.—W. S. Shamban
Vice Pres., Mfg.—Henry Traub
Vice Pres., Eng.—Frank Chaffin
Sls. Mgr.—Carl Wolff

★*Sierra Electric Corp., Gardena (C, I, T)
Compression Presses: 22–50 ton to 150 ton; 62–100 ton to 750 ton
Injection machines: 4–4 oz. to 12 oz.
Transfer presses: 28–50 ton to 500 ton
Pres., Sls. Mgr.—Lee T. Bordner
Vice Pres., Plant Mgr.—Ray L. Lewis
Pur. Agt.—Ron Hills

***Westland Plastics, Inc.,** Los Angeles (I)
Injection Machines: 1–2 oz.; 5–12 oz.; 2–16 oz.
Pres.—Fred O. Forsman
Vice Pres.—Russ Forsman
Sls. Mgr.—Bert Murman
Pur. Agt.—Guss Forsman

***Wilcox Plastics, Inc.,** Montebello (C, I, T)
Compression Presses: 16–50 ton to 300 ton
Injection Machines: 3–6 oz.
Transfer Presses: 10–150 ton

Williams Mfg. Co., Inc., Anaheim (I)
Injection Machines: 1–8 oz.
Pres., Pur. Agt.—Reese Baker
Vice Pres.—Kenneth Williams
Sls. Mgr.—Ray N. Valind

***Windman Bros.,** Los Angeles (C, I, T)
Compression Presses: 20–100 ton to 400 ton
Injection Machines: 11–6 oz. to 24 oz.
Transfer Presses: 6–100 ton to 400 ton
Sls. Mgr.—Murray Windman
Pur. Agt.—Oscar Windman

COLORADO

***Bohannon Industries,** Colo. Springs (I)
Injection Machines: 1–1/10 oz.; 1–¼ oz.; 1–3/10 oz.; 1–½ oz.; 1–1 oz.

***Chaney Plastic Molding Co.,** Denver (E)
Injection Machines: 4–6 oz. to 12 oz.
Pres., Sls. Mgr., Pur. Agt.—J. E. Chaney

***Pikes Peak Plastics, Inc.,** Colorado Springs (C, I)
Compression presses: 2–50 ton
Injection machines: 1–1 oz.; 1–4 oz.
Pres.—Egon W. G. Wieselmann
Vice Pres.—Florence E. Wieselmann

***Reinhardt Plastics Co.,** Denver (C, I, T)
Compression Presses: 2: 1–35 ton, 1–125 ton
Injection Machines: 3–1 oz. to 6 oz.
Transfer Presses: 1–35 ton
Pres., Sls. Mgr.—Henry R. Reinhardt

***Rogers, V. F.,** Denver (C, I, T)
Compression Presses: 2–18 ton; 1–50 ton
Injection Machines: 1–1 oz.
Transfer Presses: 1–50 ton
Pres.—V. F. Rogers

***Sawaya Manufacturing Co., Inc.,** Trinidad (C, E, I)
Compression Presses: 5–150 ton, 1–250 ton
Extrusion Machines: 1–2½", 1–3½"
Injection Machines: 1–1 to 3 oz.
Pres., Sls. Mgr., Pur. Agt., Jess Sawaga

Seder Plastic Corp., Ft. Collins (C, I, T)
Compression presses: 3–15 ton; 15–30 ton; 1–85 ton; 1–200 ton; 3–500 ton
Injection machines: 1–1 oz.; 1–2½ oz.; 1–9 oz.
Transfer presses: 1–35 ton; 1–50 ton; 1–200 ton
Pres., Sls. Mgr.—John Gano Seder
Vice Pres.—Stan Colson
Treas.—C. F. Wolfer
Pur. Agt.—Gertrude Collier

Yorker & Sons, Inc., Denver (I)
Injection Machines: 1–2 oz., 1–4 oz., 2–8 oz., 1–12 oz.
Pres., Pur. Agt.—Col. Oscar B. Yorker
Vice Pres.—Scott A. Gale
Sls. Mgr., Gen. Mgr.—Jack R. Pechman

CONNECTICUT

Atlantic Plastics, Inc., Stamford (I)
Injection Machines: 4–2 oz., 2–4 oz., 5–12 oz.
Pres.—Neil S. Waterman
Treas.—Robert J. Greenlaw

***Bridgeport Moulded Products, Inc.,** Fairfield (C, I, T)
Compression presses: 1–15 ton; 5–50 ton; 8–100 ton; 4–300 ton
Injection machines: 2–2 oz.; 1–4 oz.; 2–6 oz.; 2–8 oz.; 5–12 oz. to 20 oz.; 1–32 oz.; 1–48 oz.; 1–60 oz.; 1–200 oz.
Transfer presses: 14–50 ton; 11–150 ton; 1–200 ton
Pres.—L. P. Clark
Vice Pres.—D. R. Neary
Sls. Mgr.—J. R. Todd
Pur. Agt.—C. Giles

★Butterfield, T. F., Inc., Naugatuck (C, I, T)
Compression presses: 5–50 ton; 35–100 ton; 1–125 ton; 1–300 ton
Injection machines: 7–2 to 8 oz.
Transfer presses: 7
Pres.—C. E. Butterfield I
Vice Pres.—T. F. Butterfield
Sales Mgr.—R. W. Van Riper, Jr.
Pur. Agent.—J. F. McGroary

***Colts Plastics Co., Inc.,** N. Grosvenordale, Conn. (C, E)
Compression Presses: 11 automatic; 35 compression
Injection Machines: 12–1½ oz. to 12 oz.
Pres.—Leonard Salmanson
Vice Pres.—Donald Salmanson
Sls. Mgr.—Gregory J. Azarian
Pur. Agt.—Lester Trouton

★*Connecticut Plastic Products Co., Waterbury (I)
Injection Machines: 4–2 oz.; 1–4 oz.; 4–8 oz.; 1–12 oz.; 2–16 oz.
Pres., Sls. Mgr.—M. F. Sullivan
Vice Pres.—C. J. Sullivan
Pur. Agt.—J. F. Duer

Danielson Mfg. Co., Sub. of Nicholson File Co., Danielson (E, I)
Extrusion machines: 5–1½" to 3½"
Injection machines: 2–½ oz., 3–1 oz., 3–2 oz., 9–4 oz., 1–5 oz., 3–8 oz., 4–12 oz.
Pres.—Robert P. Hopgood
Sales Mgr.—Nathan A. Freuden
Pur. Agt.—Edward LaFantasie

***Derby-Shelton Silver Co., Stelray Products, Inc. (Plastics Div.),** Shelton (I)
Injection Machines: 5–2 to 8 oz., 3–12 oz.
Pres.—R. R. Luben

***Engineered Plastics, Inc.,** Watertown (C, T)
Compression presses: 4–50 ton; 2–115 ton; 1–150 ton
Transfer presses: 4–50 ton; 2–115 ton; 1–150 ton
Pres.—Alexander L. Alves
Vice Pres. & Sales Mgr.—Ray L. Henderson
Pur. Agt.—John Ferguson

***Gilman Brothers Co., The,** Gilman (E)
Extrusion machines: 4

★*Jessall Plastics, Inc., Kensington (E)
Extrusion machines: 2–2"; 3–2½"; 1–3¼"; 1–4½"
Gen. Mgr.—J. B. Capella
Asst. Gen. Mgr.—Dale Hays
Sls. Mgr.—Edward J. McDonald, Jr.
Pur. Agt.—Jerry Smith

***Joclin Mfg. Co.,** Wallingford (C)
Compression presses: 14–250 ton
Pres.—C. M. Doede
Sls. Mgr.—David R. Lurie
Pur. Agt.—S. F. DiGiorgi

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* Operates own tool room
★ Indicates Advertiser

***Meriden Molded Plastics, Inc.,** Meriden (C)
Compression presses: 41–10 ton to 750 ton
Pres.—George C. Dickson
Vice Pres.—George F. Dickson
Sales Mgr.—John N. Campbell
Pur. Agt.—Sophie K. Hull

***Monaplastics, Inc.,** Georgetown (I)
Injection machines: 2 oz.; 4 oz.; 6 oz.; 8 oz.; 12 oz.

***Plastic Products, Inc.,** S. Norwalk (C, I, T)
Compression Presses: 30–50 ton to 300 ton; 10 Automatic
Injection Machines: 3–4 oz. to 22 oz.
Transfer Press: 10–50 ton to 500 ton
Pres.—M. B. Hemming
Vice Pres., Sls. Mgr.—A. J. Lilliedahl
Pur. Agt.—D. L. Sherman

Rich Plastic Products, Meriden (C, T)
Compression Presses: 50–15 ton to 300 ton
Transfer Presses: 6–50 ton to 150 ton
Pres.—Joseph Rich
Sls. Mgr., Pur. Agt.—Daniel J. Rich

***Rowland Products, Inc.,** Kensington (E)
Extrusion machines: 10—up to 3½"
Pres.—Hugh Rowland
Vice Pres., Sec.—William P. Rowland
Vice Pres., Sls. Mgr.—Thomas D. Hogan
Pur. Agt.—Robert E. Randall

★**Stanley Chemical Co., The,** East Berlin (I)
Injection Machines: 3–3 oz., 2–6 oz.

***U. S. Plastic Molding Corp.,** Wallingford (C, I, T)
Compression presses: 5–40 ton; 6–50 ton; 9–75 ton; 6–200 ton
Injection machines: 1–2 oz.; 1–9 oz.; 1–16 oz.
Transfer presses: 1–75 ton; 2–100 ton; 3–150 ton; 1–250 ton; 1–450 ton
Pres.—Peter Barberino
Vice Pres.—J. L. Raesler
Sls. Mgr.—Robert Flagg
Pur. Agt.—H. S. Schenck

***United Tool Co.,** Bridgeport (I)
Injection machines: 1–4 oz. to 6 oz.; 2–6 oz. to 8 oz.; 1–12 oz.
Pres.—E. G. Hultgren
Vice Pres.—K. M. Hultgren
Sls. Mgr.—G. W. Hultgren

Vogel Mfg. Co., The, Bridgeport (I)
Injection Machines: 1–2 oz.; 1–3 oz.; 1–4 oz.; 1–8 oz.; 3–16 oz.
Pres.—Rudolf Vogel
Treas.—Max Schwartz

★***Waterbury Companies, Inc.,** Waterbury (C, I)
Compression Presses: 8–30 ton; 1–42 ton; 3–50 ton; 5–60 ton; 8–75 ton; 1–100 ton; 6–120 ton; 15–170 ton; 5–300 ton; 1–700 ton
High-speed Plunger Presses: 15–170 ton; 2–230 ton; 2–300 ton
Injection Machines: 3–4 oz.; 3–6 oz.; 7–8 oz.; 2–10 oz.; 1–16 oz.; 2–22 oz.; 1–32 oz.
Pres.—L. P. Sperry, Jr.
Vice Pres.—W. F. Reibold
Sls. Mgr.—G. A. Walker
Pur. Agt.—F. Johnson

★***Watertown Mfg. Co., The,** Watertown (C, I)
Compression presses: 70–50 to 450 ton
Injection machines: 12–2 to 64 oz.
Pres.—J. R. Neill
Vice Pres. & Sls. Mgr.—G. G. Welch
Secy.—H. J. Weisman
Treas.—C. M. Siemon
Pur. Agt.—C. M. Siemon, Jr.

DELAWARE

★***Continental-Diamond Fibre Corp., Sub. of The Budd Co.,** Newark (C, I, T)
Compression Machines: 98
Injection Machines: 1–16 oz.
Transfer Presses: 3
Vice Pres., Gen. Mgr.—H. K. Collins

Vice Pres.—F. M. Grauer, E. O. Hausmann
Sls. Mgr.—A. J. Briggs
Pur. Agt.—W. H. Walker, Jr.

FLORIDA

Helmac Plastics, Inc., Pinellas Park (I)
Injection Machines: 1–1½ oz., 1–4 oz., 1–9 oz.
Pres., Sls. Mgr., Pur. Agt.—Owen S. Riffle
Vice Pres.—Wenzel J. Ryshavy

***Industrial Vinyls Inc.,** Miami (E)
Extrusion machines: 3–3½", 1–4½", 1–1"
Pres.—G. W. Cornell
Vice Pres.—G. R. Waugh, Jr.
Sls. Mgr.—E. J. Wilborg

***Modern Designers,** Hialeah (I)
Injection machines: 2–2½ oz.
Pres., Sls. Mgr.—Martin L. Dawson
Vice Pres.—Douglas M. Dawson
Pur. Agt.—Donald M. Dawson

***Pioneer Plastics,** Jacksonville (I)
Injection machines: 7–2 to 4 oz.
Pres.—William T. Strom

***Plastex Laminates, Inc.,** Hialeah (CM)
Pres.—S. Ronald Barnette

***Security Plastics, Inc.,** Hialeah (I)
Injection machines: 1–2½ oz.; 2–4 oz.; 1–8 oz.
Pres., Sls. Mgr.—Norman H. Cohan
Vice Pres., Pur. Agt.—Fredric Wise

GEORGIA

Lamex, Inc., Norcross (E)
Extrusion machines: 8
Pres.—W. R. McKelvy
Vice Pres.—M. J. McKelvy
Sls. Mgr.—A. P. Morley
Pur. Agt.—M. G. Hoffman

***Textile Rubber Co., Inc.,** Bowdon (C, E, I)
Compression presses: 12–2 opening, 24" x 24"; 1–5 opening, 32" x 52"
Extrusion machines: 1–2½"
Injection machines: 3–8 oz.; 3–12 oz.
Pres.—Etoile Davis
Sls. Mgr.—W. W. Copeland
Vice Pres.—Mrs. W. D. Stokes

ILLINOIS

***A & O Plastics Co.,** Downers Grove (I)
Injection machines: 3–6 oz.
Pres., Sls. Mgr., Pur. Agt.—A. Nease
Vice Pres.—O. Nease

***Advance Molded Plastics Corp.,** Chicago (C, I, T)
Compression presses: 8–up to 400 ton
Injection machines: 2–16 oz.; 1–4 to 6 oz.
Transfer presses: 7
Pres., Sales Mgr.—R. S. Amrine
Vice Pres., Pur. Agt.—George Mottl

***Anesite Co.,** Chicago (E)
Extrusion Machines: 7–4½"
Pres.—William L. Hess
Vice Pres.—G. L. Hess
Sls. Mgr.—E. K. Kalla
Pur. Agt.—Arthur Morf

★***Artag Plastics Corp.,** Chicago (I)
Injection Machines: 20: 2–7 oz.; 12–8 oz.; 6–16 oz.
Pres.—Arthur Weis
Vice Pres., Pur. Agt.—Edward E. Heck
Sls. Mgr.—Robert Reynolds

***Becwar Mfg. Corp.,** Addison (I, T)
Injection Machines: 8
Transfer Presses: 1
Pres.—R. A. Becwar
Sales Mgr.—B. J. Dieschbourg
Pur. Agt.—A. L. Wolf

★***Blackhawk Molding Co., Inc.,** Addison (I)
Injection Machines: 8–from 4 oz. to 16 oz.
Pres.—Walter E. Hidding
Vice Pres.—J. W. Hidding
Sls. Mgr.—Wm. M. Carlson
Pur. Agt. Daniel P. Hidding

Breyer Molding Co., Chicago (C, I, T,)
Compression presses: 15 to 1,000 ton
Injection machines: 9–4 oz to 90 oz.
Transfer presses: 2–250 ton
Pres.—S. J. Stone
Sales Mgr.—Charles Schiff
Pur. Agt.—Wm. E. Hinchsliff

***Cameron, Inc.,** Chicago (I)
Injection Machines: 4–8 oz.; 10 oz.; 12 oz.; 16 oz.
Pres. & Sales Mgr.—L. C. Dunn
Vice Pres. & Pur. Agt.—R. O. Nelson

★***Chicago Molded Products Corp.,** Chicago (C, I)
Compression Presses: 3 Automatics; 4–75 ton; 10–120 ton; 12–170 ton; 10–200 ton; 1–250 ton; 8–300 ton; 6–380 ton; 2–470 ton; 6–520 ton; 1–750 ton; 2–1200 ton; 2–1500 ton
Injection Machines: 1–2 oz.; 3–4 oz.; 14–8 oz.; 4–16 oz.; 3–32 oz.; 1–64 oz.
Pres., Gen. Mgr.—John J. Bachner
Vice Pres., Div. Mgr.—James E. Johnston
Pur. Agt.—F. F. Klingenmeier

***Chicago Plastic Products Co., Inc.,** Chicago (I)
Injection Machines: 1–8 to 10 oz.
Pres.—Dr. William Scholl
Vice Pres., Sls. Mgr.—R. E. Williams
Pur. Agt.—D. M. Marsh

***Chicago Wood & Plastic Products,** Chicago (C, I, CM)
Compression Presses: 8
Injection Machines: 1–4 oz.; 6–64 oz.
Pres.—John Buel
Vice Pres., Sls. Mgr.—L. R. McCormick
Pur. Agt.—George Jameson

Chris Kaye Plastics Mfg. Co., Madison (I)
Injection machines: 6–4 to 16 oz.
Pres.—Christ D. Kacalieff

★***Commercial Plastics Co.,** Chicago (E, I)
Extrusion Machines: 1–1½"; 2–2½"; 1–3½"
Injection Machines: 1–4 oz.; 1–6 oz.; 1–8 oz.; 1–9 oz.; 1–12 oz.; 1–24 oz.
Pres.—Frank A. Allseits
Vice Pres., Sls. Mgr.—Andrew J. Fischer
Pur. Agt.—M. Kressman

***Continental Plastic Corp.,** Chicago (I)
Injection Machines: 8–8 oz. to 24 oz.
Pres., Vice Pres., Sls. Mgr.—R. W. Linehan
Pur. Agt.—W. Boysen

***Cumberland Tool Works,** Chicago (I)
Injection machines: 3–2 oz.

★**Custom Plastics, Inc.,** Melrose Park (E)
Extrusion Machines: 1–1½"; 3–2½"
Pres., Pur. Agt.—Cosmo N. Tisbo
Vice Pres.—Jerry D. Ranieri
Sls. Mgr.—Milton Nouzak

★***Davies, Harry, Molding Co.,** Chicago (C, T)
Compression presses: 25–75 to 300 ton
Transfer presses: 15–130 to 300 ton
Pres.—J. F. Davies
Vice Pres.—G. E. Mullens
Vice Pres. & Sls. Mgr.—R. C. Appleby
Pur. Agt.—I. Haugen

***Dielectric Materials Co.,** Chicago (E)
Extrusion machines: 2–3½"; 2–2½"; 2–1½"
Pres.—H. D. Isenberg
Vice Pres. & Pur. Agt.—O. C. Muenzer

***Eclipse Manufacturing Co.,** Lake Zurich (C, I, T)
Compression presses: 10–50 to 500 ton
Injection machines: 9 oz. to 24 oz.
Transfer presses: 240, 250, 300 ton

***Federal Tool Corp.,** Chicago (E, I)
Extrusion machines: 3–2½"; 3½"; 4½"
Injection machines: 33–2 oz. to 300 oz.
Pres. R. Bernhardt
Vice Pres.—J. Press
Vice Pres. & Sls. Mgr.—R. Winter
Pur. Agt.—F. Sanders

G. Felsenthal & Sons, Chicago (I)
Injection machines: 20–4 oz. to 80 oz.
Pres.—Ben W. Rau
Vice Pres. & Sls. Mgr.—Earl R. Keown
Pur. Agt.—Bert Fredrickson

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* Operates own tool room
★ Indicates Advertiser

★*General American Transportation Corp., Plastics Div., Chicago (C, I, E)
Compression presses: 350 to 2000 tons
Extrusion machines: 2½" to 4½"
Injection machines: 2 oz. to 300 oz.
Pres.—William J. Stebler
Gen. Mgr.—Harry M. Jenkins
Supv. of Sales—James Nash
Pur. Agt., Plastics Div.—Robert B. Silverman
Dir. of Res. & Dvlpt.—Carl F. Massopust

***General Die Mold Co.,** Chicago (C, I, T)
Compression presses: 12—25 to 450 ton
Injection machines: 2—6 oz.; 1—9 oz.; 2—24 oz.; 1—32 oz.; 1—60 oz.
Transfer presses: 4—150 ton
Pres.—Rose Nagy
Vice Pres., & Pur. Agt.—E. A. Berecz
Vice Pres., Sales—S. T. Edlis

***General Molded Products, Inc.,** Des Plaines (C, I, T)
Compression presses: 5—50 ton; 1—150 ton; 2—200 ton; 1—300 ton; 1—750 ton
Injection machines: 1—5 oz.; 1—6 oz.; 1—16 oz.; 1—24 oz.
Transfer Presses: 1—50 ton, 2—200 ton; 3—300 ton
Pres.—Norman Anderson
Vice Pres.—Carl J. Sanders
Sales Mgr.—Donald E. Goll
Pur. Agt.—Harold Matheson

***Gits, J. P., Molding Corp.,** Chicago (I)
Injection machines: 23—2 oz. to 90 oz.
Pres.—Jules P. Gits
Vice Pres.—Jules C. Gits
Sales Mgr.—John R. Gits
Pur. Agt.—Cas Giesel

***Globe Imperial Div., Ainsworth-Precision Castings Co.,** Rockford (C, I, T)
Compression presses: 6—75 ton; 2—150 ton
Injection machines: 1—4 oz.; 4—8 oz.; 2—29 oz.
Transfer presses: 7—150 ton to 350 ton
Exec. Vice Pres.—J. F. McDonnell, Jr.
Vice Pres.—E. L. Anderson
Sls. Mgr.—Art Witt (Cleveland)
Pur. Agt.—D. R. Simmons

***Grayhill Moldtronics, Inc.,** LaGrange (C, T)
Compression presses: 3—3½ ton; 1—20 ton; 1—50 ton
Transfer presses: 17—10 ton
Pres.—Ralph M. Hill
Vice Pres.—Gordon E. Gray
Gen. Mgr.—Kasimir J. Skvorc
Sales Mgr.—George A. Scherry
Pur. Agt.—Alfred P. Urban

***Grigoleit Co., The,** Decatur (C, I, T)
Compression presses: 90—30 ton to 600 ton
Injection machines: 4—4 oz. to 12 oz.
Transfer presses: 15—100 ton to 300 ton
Pres.—J. L. Howie, Jr.
Vice Pres. & Gen. Mgr.—R. K. Howie
Sales Mgr.—Carl A. Goltermann
Pur. Agt.—A. P. McMinn

Goren Co., H. L., Chicago (E)
Extrusion Machines: 1—8"
Pres.—Herbert L. Goren
Vice Pres., Pur. Agt.—A. B. Tenenbaum
Sls. Mgr.—Daniel Markin

***Heine Industries, Inc.,** Freeport (C, I, T)
Compression presses: 15—50-250 ton
Injection machines: 2—2½ oz.
Transfer presses: 12—65-250 ton
Pres.—Lorton Heine
Gen'l. Mgr.—Russell Cole

★Holland, M., Co., Chicago (E)
Extrusion machines: 4
Pres.—M. Holland
Sls. Mgr. & Pur. Agt.—E. Pignataro

***I-V Die Mold Co.,** Peoria (C, I)
Compression Presses: 1—10 ton
Injection Machines: 2—2 oz.; 2—½ oz.

★*Industrial Molded Products Co., Inc., Palatine (C, I, T)
Compression Presses: 1—88 ton; 10—100 ton; 3—150 ton
Injection machines: 1—4 oz.; 1—8 oz.; 1—16 oz.

Transfer presses: 3—200 ton, 1—300 ton
Pres. & Sls. Mgr.—Carl E. Benson
Vice Pres. & Pur. Agt.—Peter C. Barsanti

***Johnson Glass & Plastic Corp.,** Chicago (I)
Injection machines: 5—4 oz. to 20 oz.
Pres.—William W. Garland
Pur. Agt.—H. Edison Garland

***Joliet Plastic, Inc.,** Joliet (I)
Injection machines: 4
Pres., Sls. Mgr. & Pur. Agt.—Marcus A. Kozan

★*Keolyn Plastics, Inc., Chicago (I)
Injection machines: 2—16 oz.
Pres.—W. D. McKay
Vice Pres.—J. E. Glatt, J. J. Detzel
Sls. Mgr.—J. E. Glatt
Pur. Agt.—W. D. McKay

★*Korris Products, Inc., Lyons (I)
Injection machines: 1—2 oz.; 4—8 oz.; 4—16 oz.; and 2—24 oz.
Pres. & Sls. Mgr.—Charles Youdris
Vice Pres.—Lido Albiani
Pur. Agt.—Edward J. Koren

***Lind Plastic Products, Inc.,** Chicago (C, I)
Extrusion Machines: 2—4½"
Injection Machines: 1—4 oz.; 11—8 oz.
Pres.—Carl J. Lind
Vice Pres., Pur. Agt.—G. M. Baccash

***Master Molded Products Corp.,** Skokie (I)
Injection machines: 1—4 oz. to 6 oz.; 2—12 oz.; 1—16 oz.
Pres. & Pur. Agt.—Martin Weinhart
Vice Pres. & Sales Mgr.—Thomas Reagan

***Mayfair Molded Products,** Schiller Park (C, I, T)
Compression presses: 40—Up to 300 ton
Injection machines: 5—From 2½ oz. to 10 oz.
Transfer presses: 4—Up to 300 ton
Pres.—Elmer B. Ott
Vice Pres., Gen. Mgr., Pur. Agt.—Robert E. Theis

★*Midwest Plastic Products Co., Chicago Heights (E)
Extrusion machines: 2—2½"; 2—3½"; 1—4½"
Pres.—C. C. Whitacre
Vice Pres.—E. E. Eckenbeck

***Molex Products Co.,** Brookfield (C, I, T)
Compression presses: 12
Injection machines: 2
Transfer presses: 2
Pres., Sls. Mgr.—J. H. Krehbiel
Pur. Agt.—Art Schroeder

★*National Lock Co., Rockford, Ill. (C, I, T)
Compression Machines: 2—10 ton; 1—750 ton
Injection Machines: 2—4/6 oz.; 2—12/16 oz.; 4—8 oz.; 1—24 oz.
Transfer Presses: 4—50 ton; 2—100 ton; 13—250 ton
Pres.—A. J. Strandquist
Vice Pres.—M. A. Sommer
Sls. Mgr.—S. O. Koberg
Pur. Agt.—C. M. Oberling

Peoria Plastic Co., E. Peoria (I)
Injection machines: 2—8 oz.; 1—12 oz.; 1—16 oz.; 2—48 oz.
Pres.—R. W. Wendland
Vice Pres. & Sls. Mgr.—W. M. Chinuge
Pur. Agt.—E. F. Malchow

***Perfex Plastics Inc.,** Chicago (E, I)
Extrusion machines: 6
Injection machines: 3
Pres.—Ben B. Manaster
Sls. Mgr.—Earl Wilson
Pur. Agt.—Stanley Ehrenberg

***Plano Molding Co.,** Plano (C, I, T)
Compression presses: 5—60 to 200 ton
Injection machines: 10—4 to 32 oz.
Transfer presses: 5—30 to 400 ton
Pres. & Gen. Mgr.—J. L. Henning
Vice Pres. & Sls. Mgr.—R. C. Yunger
Pur. Agt.—L. E. Phelps

***Plastic Molded Products Co.,** Chicago (I)
Injection machines: 2—36 oz.; 1—12 oz.; 1—10 oz.; 3—8 oz.; 1—4 oz.
Pres.—H. H. Brandt
Sls. Mgr.—C. Trabor

***Plastic Precision Parts Co.,** Chicago (C, I, T)
Compression presses: 1
Injection machines: 5
Transfer presses: 7
Gen. Mgr.—Wm. Slominski
Pur. Agt.—M. H. Winokur

***Polymold Plastics, Inc.,** Chicago (I)
Injection machines: 12—2 to 20 oz.
Pres.—Ben Polikoff
Vice Pres., Gen. Mgr.—John C. Porcelli

★*Process Gear Co., Chicago (I)
Injection machines: 4—3 oz.
Pres., Sls. Mgr.—H. J. Monger
Pur. Agent—Len Wichman

***Pyramid Plastics, Inc.,** Chicago (E)
Extrusion Machines: 6—2" x 2½"
Pres.—James A. Palmer
Vice Pres.—R. J. Huber
Sls. Mgr.—Webster D. Paton

***Republic Molding Corp.,** Chicago (I)
Injection Machines: 24—8 oz. to 120 oz.
Pres.—Bertram W. Coltman
Vice Pres.—Bertram W. Coltman, Jr.
Sls. Mgr.—Bart McCloskey
Pur. Agt.—Richard Klebbe

***Resincraft Plastics, Inc.,** Chicago (E)
Extrusion Machines: 1—1"; 3—2½"; 1—3½"
Pres.—Stanley Wexler
Vice Pres.—Leonard Becker

★Resinoid Engineering Corp., Skokie (C)
Compression presses: 16
Pres. & Treas.—Clarence A. Herbst, Sr.
Vice Pres.—Clarence A. Herbst, Jr.

Richardson Co., The, Melrose Park (C, T)
Vice Pres.—R. W. Jorgensen
Pur. Agt.—B. L. Allen

***Rockford Molded Products, Inc.,** Rockford (C, I, T)
Compression Presses: 2—100 ton
Injection Machines: 2—2 oz.; 3—4 oz.; 2—12 oz.
Transfer Presses: 1—100 ton; 1—200 ton; 1—300 ton
Pres., Gen. Mgr.—Henry W. Gustafson
Sec., Treas.—Norman C. Johnson

★*Rogan Brothers, Skokie (C, T)
Compression Presses: 6—15 ton, 8—50 ton, 4—125 ton, 2—150 ton
Transfer Presses: 2—150 ton
Partners—Ed Rogan, J. J. Rogan

***Romar Plastics, Inc.,** St. Charles (C, I, T)
Compression Presses: 8—40 ton to 250 ton
Injection Machines: 4—4 oz. to 16 oz.
Transfer Presses: 4—88 ton to 250 ton
Pres.—R. E. Peterson
Gen. Mgr.—John C. Balazs
Sls. Mgr.—C. W. Peterson
Pur. Agt.—G. A. Hart

***S-K-W Mfg. Co.,** Chicago (I)
Injection machines: 2—2 oz.; 8—6 oz.; 3—12 oz.
Pres.—Bernard J. Skorvpa
Vice Pres.—Roy Hobson
Pur. Agt.—Chas. MacDowall

***Sandee Mfg. Co.,** Chicago (E)
Pres.—Elmer Szantay
Sls. Mgr.—James Clemens
Pur. Agt.—J. Claerhout

★*Service Plastics, Inc., Chicago (I)
Injection machines: 1—2 oz.; 1—4 oz.; 1—8 oz.; 3—12 oz.; 2—20 oz.; 1—32 oz.; 1—48 oz.; 1—80 oz.; 1—85 oz.
Pres., Pur. Agt.—Maurice Meltzer
Vice Pres.—Charles Karels

★*Sinko Mfg. & Tool Co., Chicago (I)
Injection machines: 18—2 oz. to 175 oz.
Pres.—John Sinko
Vice Pres.—Jack High
Sls. Mgr.—Fred Welz
Pur. Agt.—H. O. Nielsen

***Stimsonite Division, Elastic Stop Nut Corp. of America,** Chicago (I)
Injection Machines: 5—16 oz., 2—32 oz., 3—9 oz., 2—12 oz., 1—4 oz., 1—15 ton; 1—450 ton
Gen. Mgr.—H. A. Doolittle

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* Operates own tool room
★ Indicates Advertiser

★***Superior Plastics, Inc.,** Chicago (E, I)
Extrusion Machines: 6–2½" and 3½"
Injection Machines: 18–4 oz. to 32 oz.
Pres.–Harry Scheer
Vice Pres., Sls. Mgr.–R. S. Bezark
Vice Pres.–Louis Levine
Pur. Agt.–L. Guth

Tietz & Bauer Plastics, Inc., Melrose Park (C, T)
Compression Presses: 24–up to 350 ton
Transfer Presses: 4–up to 350 ton
Pres.–William F. Bauer
Vice Pres.–Paul C. Tietz, Jr.
Pur. Agt.–E. Adams

★***Trans-Matic Mfg. Co.,** Chicago (C, T)
Compression Presses: 13
Transfer Presses: 10
Pres.–Stephen J. Handzel
Vice Pres.–Robert Podalski
Sls. Mgr.–Helen H. Wielgus
Pur. Agt.–Edward Wolanin

***20th Century Plastics Co.,** Chicago (I)
Injection Machines: 2–4 oz.; 5–16 oz.; 1–20 oz.
Pres.–Nathan Nudelman
Sls. Mgr.–Joseph H. DeSobe
Plant Mgr.–Bernard Willow
Pur. Agt.–Josephine Bavaro

***Van Norman Molding Co.,** Chicago (C, T)
Compression Presses: 19: 15 to 200 ton
Transfer Presses: 5: 75 to 200 ton
Pres., Sls. Mgr.–G. E. Andre
Vice Pres.–R. I. Andre
Pur. Agt.–R. Harrison

Victory Mfg. Corp., Chicago (I)
Injection Machines: 17–up to 60 oz.

***Whitso, Inc.,** Schiller Park (C, I, T)
Compression Presses: 3–88 ton
Injection Machines: 2–4 oz. to 12 oz.
Transfer Presses: 17–88 ton to 150 ton
Pres.–John B. Whitted
Vice Pres.–John B. Whitted, Jr.
Sls. Mgr.–Wm. Brown

★***Zollinger, Albert, Inc.,** Downers Grove (C, I, T)
Compression Presses: 2–25 ton automatic
Injection Machines: 1–6 oz.
Transfer Presses: 10–75 to 300 ton
Pres.–Albert Zollinger
Vice Pres., Pur. Agt.–Robert Zollinger
Sls. Mgr.–Norman Zollinger

INDIANA

A G P Corp., Peru (I)
Injection machines: 2–2 oz.; 1–3 oz.; 1–6 oz.; 3–8 oz.; 1–16 oz.
Pres.–G. L. Lawrence
Vice Pres.–C. Lyman Hall
Sales Mgr.–John E. King
Pur. Agt.–Gerald Ellars

★***Amos Molded Plastics Div., Amos-Thompson Corp.,** Edinburg (I)
Injection Machines: 1–2 oz.; 2–4 oz.; 1–8 oz.; 3–12 oz.; 3–16 oz.; 2–24 oz.; 3–32 oz.; 1–42 oz.; 2–48 oz.; 2–64 oz.; 2–200 oz.
Pres.–Dale Amos
Vice Pres.–J. G. Kazimier
Sls. Mgr.–Frank D. Deli
Pur. Agt.–W. Parmer

Calumet Fiberglass Products Co., Hammond (C)
Compression Presses: 2
Pres.–Christopher Argus

★***Como Plastics, Inc.,** Columbus (I)
Injection Machines: 1–6 oz.; 2–4 oz. to 6 oz.; 2–8 oz.; 3–12 oz.; 2–16 oz.; 2–20 oz. to 28 oz.; 1–200 oz.
Pres., Sls. Mgr.–James L. Russell
Vice Pres.–Oscar Daffron
Pur. Agt.–Lowell Daffron

★***Crescent Plastics, Inc.,** Evansville (E)
Extrusion Machines: 11–up to 4½"
Pres.–John H. Schroeder
Vice Pres.–Clem J. Young
Sls. Mgr.–Donald B. Korb, Ed. S. Schreiber
Pur. Agt.–Robert Bock

***Engineered Nylon Products, Inc.,** Elkhart (I)
Injection machines: 4–4 oz.; 3–8 oz.; 1–12 oz.
Pres.–R. W. Bosse
Vice Pres.–Phil Rotzien
Sales Mgr.–William C. Holden

★***General Plastics Corp.,** Marion (E)
Extrusion machines: 2–3½"
Pres. and Sales Mgr.–R. H. Erlewine
Vice Pres. and Pur. Agt.–C. W. Richter

***Industrial Plastics Corp.,** Elkhart (E)
Extrusion machines: 1–1½"; 2–3½"; 4– 2½"
Pres. & Sls. Mgr.–C. Aird Moffat
Vice Pres.–R. K. Moffat
Gen. Mgr. & Pur. Agt.–L. J. Swift

***Kenly Co.,** Terre Haute (E, I)
Extrusion machines: 2½"
Injection machines: 1–6-8 oz.; 1–9 oz.; 1–12 oz.; 1–16 oz.

Kent Plastics Corp., Evansville (E, I)
Extrusion machines: 1–2½"; 2–4½"
Injection machines: 1–4 oz.; 4–8 oz.; 2–12 oz.; 2–16 oz.; 1–24 oz.; 2–32 oz.; 1–48 oz.; 1–64 oz.
Pres.–R. H. Morehouse
Sls. Mgr.–J. N. Ruthenburg
Pur. Agt.–Wm. H. Brooks

Niles Corp., South Bend (I)
Injection machines: 1–8 oz.; 1–4 oz.
Pres. & Sls. Mgr.–Loren Schafer

Nyloncraft, Inc., Mishawaka (I)
Injection machines: 3–4 oz.; 2–8 oz.; 8–12 oz.
Pres.–James F. Wyllie
Vice Pres.–Charles J. Foret

***Plastic Service Corp.,** LaPorte (C, I, T)
Compression presses: 14–00 ton-750 ton;
Injection machines: 2–9 oz. and 48 oz.
Transfer presses: 2–200 ton and 300 ton
Pres.–Herbert C. Grau
Vice Pres. & Sls. Mgr.–Leonard R. Cooper
Pur. Agt.–R. O. Stanford

★**Polygon Plastic Co.,** Walkerton (E)
Extrusion machines: Fibrous glass extrusion machines; patented continuous process
Pres.–S. M. Shobert
Vice Pres.–G. S. Parks
Sales Mgr.–E. R. Jacques

Pribble Plastics Products, Inc., New Haven (C, T)
Compression presses: 2–25 ton; 2–75 ton; 1–283 ton
Transfer presses: 2–25 ton; 2–75 ton; 1–283 ton
Pres., Sls. Mgr., Pur. Agt.–Wayne I. Pribble
Vice Pres. & Plant Manager–John L. Haugsrud

***Progressive Molded Products Corp.,** Bluffton (C, T)
Compression presses: 2–50 ton; 2–200 ton; 2–300 ton
Transfer presses: 1–50 ton; 2–200 ton; 2–300 ton
Pres. & Sls. Mgr.–Philip H. Leonard
Vice Pres.–Harvey Peden

***Rostone Corp.,** Lafayette (C, T, CM)
Compression Presses: 41–5 ton to 1500 ton
Transfer Presses: 2–30 ton to 75 ton
Pres.–P. W. Jones
Vice Pres., Sls. Mgr.–M. G. Knoy
Vice Pres.–F. P. Wymer
Pur. Agt.–P. W. McQueen

***St. Regis Paper Co., Panelyte Div.,** Richmond (E)
Extrusion Machines: 1–2½"; 1–3½" 1–4½"; 1–6"

***Sheller Mfg. Corp.,** Portland (C, E, I, T)
Compression presses: 78–135 ton; 8–500 ton
Extrusion machines: 2–4" 4–6"
Injection machines: 1–8 oz.; 1–12 oz.; 2–22 oz.; 2–28 oz.; 5–40 oz.; 1–100 oz.
Transfer presses: 1–1000 ton
Pres.–T. Bradley
Vice Pres.–J. A. McKeown
Sls. Mgr.–E. J. Cosgrave
Pur. Agent.–E. J. Minch

Sobenite, Inc., South Bend (I)
Injection machines: 14–r oz. to 16 oz.

***Wayne Plastics Corp.,** Fort Wayne (C, I, T)
Compression Presses: 9–40 ton to 800 ton
Injection Machines: 1–2 oz.; 1–4 oz. to 6 oz.; 1–6 oz. to 9 oz.
Transfer Presses: 6–110 ton to 300 ton
Pres., Sls. Mgr.–W. W. Burhop
Supt.–Frank Stoffel
Pur. Agt.–Harold P. Parker, Jr.

KENTUCKY

***Tri-State Plastic Molding Co.,** Henderson (E, I)
Extrusion Machines: 1–3½"
Injection Machines: 1–2 oz.; 2–4 oz.; 9–8 oz.; 4–12 oz.; 1–16 oz.; 1–24 oz.; 1–32 oz.; 1–48 oz.
Pres.–Patrick J. Buckley
Gen. Mgr., Sls. Mgr.–Gordon R. Kay

LOUISIANA

***Dixie Plastics Mfg. Co.,** New Orleans (E, I)
Extrusion machines: 3–2 to 2½"; 1–3½"
Injection machines: 1–6 oz.
Pres.–F. L. Boylan
Vice Pres.–C. R. McCauley
Sales Mgr.–F. V. Boylan
Pur. Agt.–Thomas P. Breslin

MAINE

***Keyes Fibre Co.,** Waterville (C)
Compression presses: 1–1000 ton, 1–800 ton, 7–500 ton, 1–300 ton, 2–200 ton
Pres.–R. H. Cutting
Vice Pres., Sales–D. Archibald
Mdse. Mgr.–D. Hall
Pur. Agt.–R. Wescott

***Maine Molding Products,** Boothbay Harbor (C, T)
Compression presses: 2–75 ton; 1–800 ton
Transfer presses: 1–75 ton
Pres.–Earl J. Gaw
Vice Pres., Gen. Mgr.–Clarence Jeffrey
Sls. Mgr.–Paul J. Crosby
Pur. Agt.–J. A. Bracy

MARYLAND

***Fawn Plastics Co., Inc.,** Timonium (I)
Injection machines: 2–3 oz.; 2–6 oz.; 1–8 oz.
Pres.–Robert D. Brickett
Vice Pres.–John Franzone
Sls. Mgr.–William Reese
Pur. Agt.–Carl Neutzel

***Moldcraft, Inc.,** Baltimore (C, I)
Compression presses: 8–25 ton; 6–50 ton
Injection machines: 7–3 oz. to 16 oz.
Pres., Sls. Mgr.–David H. DeVilliers
Vice Pres., Pur. Agt.–Frank S. Nixdorff

★**National Plastic Products Co., The,** Odenton
Pres.–E. Winer
Vice Pres.–A. Winer
Sls. Mgr.–J. R. Brown
Pur. Agt.–D. J. Anderson

***Standard Cap and Molding Co.,** Baltimore (C, I)
Compression Presses: 18–Rotary
Injection Machines: 4–9 oz., 1–3 oz.
Pres.–C. M. Crowther
Vice Pres., Sls. Mgr.–C. E. Hemingway
Pur. Agt.–E. J. Nelson

***Wama Co., The,** Baltimore (C)
Compression Presses: 3–2-25 ton, 1-50 ton
Pres.–S. K. Bodine
Sls. Mgr.–H. E. Robbins
Pur. Agt.–W. D. White

MASSACHUSETTS

Bolta Products Div., The General Tire & Rubber Co., Lawrence (C, E, T)
Compression presses: 20–from 230 ton to 758 ton
Extrusion machines: 16–from 1½" to 3"
Injection machines: 20–from 6 oz. to 100 oz.
Div. Mgr.–John G. Roppel
Gen. Mgr.–Sumner L. Trilling
Research & Development Mgr.–George S. Laaff
Pur. Agt.–Wayne Grubaugh
Factory Mgr.–William F. Murphy

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* Operates own tool room
★ Indicates Advertiser

★Boston Plastic Machinery, Inc., Boston (E)
Extrusion machines: 4
Pres.—Leslie J. Kovach
Treas.—Edith Kovach
Pur. Agt.—J. Faith

*Boyden Plastics, Inc., Taunton (I)
Injection machines: 4–8 oz.; 1–16 oz.; 1–22 oz.

*Brook Molding Corp., Norwood (C,I,T)
Compression presses: 7–50 ton to 600 ton
Injection machines: 2–4 oz.; 3–12 oz.
Transfer presses: 5–50 ton to 300 ton
Pres.—F. Reed Estabrook, Jr.
Sales Mgr.—C. M. Cunningham
Pur. Agt.—F. K. Whiting

Century Plastic Co., Fitchburg (I)
Injection machines: 7–4 oz. to 22 oz.
Pres., Pur. Agt.—E. S. Sharaf
Sales Mgr.—M. H. Jaffe

Church, C. F., Div. of American-Standard, Holyoke (C, I)
Compression presses: 4–500 ton; 36–100 ton; 64–100 ton to 300 ton
Injection machines: 20–4 oz. to 60 oz.
Pres.—R. A. Witherell
Vice Pres., Plastic Prod. Sls.—E. M. Osgood
Pur. Agt.—Leland W. Shaw

Clark-Cutler & McDermott, Franklin (C)
Compression presses: 6
Pres.—F. Roland McDermott
Sls. Mgr.—Robert H. Schmitt
Pur. Agt.-Luke Murray

*Commonwealth Plastics Corp., Leominster (E, I)
Extrusion machines: 12
Injection machines: 30

*Component Mfg. Service, Inc., W. Bridgewater (C, I, T)
Compression presses: 3–30 ton; 4–2 ton
Injection machines: 30–10 oz.; 3–2 oz.
Transfer presses: 2–15 ton
Pres.—Randolph G. Barker
Sls. Mgr.—George K. Black
Pur. Agt.—Roy E. Owens

*Custom Extrusion, Inc., Sheffield (E)
Extrusion machines: 3–3¼″
Pres.—H. R. Stover
Pur. Agt.—N. C. Bennett

Dapol Plastics, Inc., Worcester (I)
Injection machines: 16–4 oz. to 48 oz.
Pres.—David Goldrosen
Vice Pres., Pur. Agt.—Louis I. Goldrosen

Duall Plastics, Inc., Athol (E)
Extrusion machines: 2–½″
Pres.—R. S. Jesionowski
Pur. Agt.—Jeanne C. Jesionowski

*Eastern Plastics Co., Inc., N. Wilbraham (I)
Injection machines: 1–4, 2–10, 1–16 oz.

★*Foster Grant Co., Inc., Leominster (I)
Injection machines: 65–2 oz. to 60 oz.
Pres.—Joseph C. Foster
Executive Vice Pres.—Dr. Robert L. Purvin
Sales Mgr.—M. W. Bernstein
Pur. Agt.—Wm. L. Gettens

*Gulliksen Mfg. Co., Wm. M., Newton Lower Falls (C, T)
Compression presses: 30–30 ton to 390 ton
Transfer presses: 20
Pres.—G. W. Olson
Vice Pres., Treas., Pur. Agt.—C. F. Wolfe
Sales Mgr.—John Prendergast Jr.

★Kingman Co., E. B., Leominster (E, I)
Extrusion machines: 2–2½″
Injection machines: 1–2 oz.; 3–4 oz.; 1–6 oz.; 8–8 oz.; 1–16 oz.; 1–20 oz.

★*Kirk Molding Co., Inc., F. J., Clinton (I)
Injection machines: 8–4 oz.; 3–12 oz.; 1–8 oz.
Pres.—Fred J. Kirk
Ass't to Pres.—Paul O. de Blois
Sls. Mgr.—Peter A. Chabot, Jr.

*Lawrence Adhesive & Chemical Co., Inc., Lawrence (C)
Compression presses: 1
Pres., Sls. Mgr.—W. J. LeBrun
Vice Pres.—A. P. McGreevy
Pur. Agt.—M. R. Hardy

★*Morningstar Corp., The, Cambridge (I)
Injection machines: 2–4 oz.; 2–8 oz.; 4–12 oz.; 4–16 oz.; 1–32 oz.
Pres.—Otto Morningstar
Sls. Mgr.—George E. Gross
Pur. Agt.—Emanuel Morningstar

*New England Tape Co., Hudson
Pres., Sls. Mgr.—Howard M. Wilkoff
Pur. Agt.—F. A. Keay

Northeastern Plastics, Inc., Boston (I)
Injection machines: 6–4 to 16 oz.
Pres.—Harry O. Sandberg
Vice Pres.—C. W. Sandberg
Pur. Agt.—Daniel Sanko

*Phoenix Plastics Corp., Clinton (E, I)
Extrusion machines: 4—various sizes
Injection machines: 2–8 oz.; 1–10 to 12 oz.
Pres., Sls. Mgr.—E. H. Jaeger
Vice Pres., Pur. Agt.—Leo J. Montagna

Plast-O-Matic Corp., Leominster (I)
Injection machines: 11–4 to 12 oz.
Pres.—Alfred G. Weaver
Vice Pres.— Seymour Thorler
Sls. Mgr.—Charles Swift
Pur. Agt.—K. Goodridge

Plastic Academy Products Corp., Leominster (I)
Injection machines: 2–2 oz.; 3–8 oz.; 3–12 oz.; 3–16 oz.; 3–20 oz.; 1–32 oz.; 1–43 oz.
Pres.—Felo Tocci
Vice Pres.—Louis Tocci
Sls. Mgr.—Ray Morse
Pur. Agt.—Alphonse Piernarini

*Plastic Industrial Products, Div. of Carlon Products Corp., Somerville (E)
Extrusion machines: 5

*Plastics Industrial Products Inc., Peabody (E)
Extrusion machines: 2–2½; 1–3½
Pres.—William Abramowitz
Vice Pres.—Eliot Kraft
Gen. & Sls. Mgr.—Saul Skoler
Pur. Agt.—Norman Mayberg

*Plastimold Corp., Attleboro (C, I)
Compression presses: 65-150 to 700 tons
Injection machines: 2–8 oz. and 24 oz.
Pres.—Lou Abrams
Vice Pres., Sls. Mgr.—John Stenberg
Pur. Agt. Gen. Mgr.—Howard Bangs

*Prolon Plastics, Florence (C, I)
Compression presses: 4–15 ton, 2–75 ton, 15–100 ton, 12–200 ton, 4–450 ton, 1–500 ton W.S., 1–500 F.O., 1–75 ton Sal press, 2 Rotary presses
Injection machines: 5–6 oz., 2–4 oz., 13–12 oz., 5–16 oz., 4–24 oz., 7–100 oz., 1–150 oz., 2–300 oz.

*R. E. C. Manufacturing Corp., Holliston (C, I, T)
Compression presses: 12–30 to 150 ton, 3–50 ton
Injection machines: 3–3 to 8 oz.
Transfer presses: 4–150 ton
Pres., Pur. Agt.—Robert E. Chick
Vice Pres.—Theodore S. Valpey
Sls. Mgr.—William S. Ewell, Jr.
Plant Supt.—Harry W. Chick, Jr.

★*Reed Plastics Corp., Worcester (E)
Extrusion machines: 4–3¼″ and 4½″
Pres.—Milton S. Sheftel
Treas.—Maurice I. Hurwitz
Sls. Mgr.—Henry W. Coz

Schreiter, Inc., F. R., Clinton (I)
Injection machines: 1–2 oz.; 3–8 oz.; 2–16 oz.; 1–22 oz.
Pres.—F. R. Schreiter

*Sheffield Plastics, Inc., Sheffield (E)
Extrusion machines: 1–2½″; 4–3¼″
Pres.—J. B. Orr
Vice Pres., Pur. Agt.—J. E. Mullen
Sls. Mgr.—F. J. Teague

Springfield Moulders, Inc., Monson (I)
Injection machines: 1–4 oz.; 3–8 oz.
Pres.—Victor Rosenlund
Vice Pres.—Gilbert E. Stacy
Treas.—Donald T. Snow

Standard Plastics Co., Inc., Attleboro (C, I, T)
Compression presses: 6–50 to 100 tons
Injection machines: 25½ to 12 oz.
Transfer presses: 2–50 tons
Pres.—Frederick V. Murphy, Jr.
Vice Pres. (Production)—Ernest E. Griffith
Vice Pres., Sls. Mgr.—Norman E. Harris

*Terkelsen Machine Co., Boston (C)
Compression presses: 25
Pres.—Albert B. Terkelsen
Vice Pres.—Jasper Derry
Sls. Mgr.—Harold A. Myers
Pur. Agt. & Treas.—Edwin A. Terkelsen

*Victory Plastics Co., Hudson (C, E, I, T)
Compression presses: 25 ton to 800 ton
Extrusion machines: 2–½″
Injection machines: 6 oz. to 100 oz.
Transfer presses: 50 ton to 200 ton
Pres.—Edwin L. Beckwith
Vice Pres., Sls. Mgr.—Charles P. Maciver
Pur. Agt.—Sherwood C. Nichols

*Worcester Moulded Plastics Co., Worcester (I)
Injection machines: 20–8 oz. to 375 oz.
Pres.,—Philip J. Graham
Treas.—Horace Gooch
Sls. Mgr.—Bertram Graham
Pur. Agt.—Ralph Williams

MICHIGAN

*Bangor Plastics, Inc., Bangor (C, T)
Compression presses: 20–30 to 640 ton
Transfer presses: 1–30 ton, 1–250 ton
Pres.—Victor Miller
Vice Pres., Sales Mgr.—E. O. Wokeck
Pur. Agt.—G. F. Wokeck

*Blue Water Plastics Co., St. Clair (I)
Injection machines: 2–4 oz. to 6 oz.; 2–12 oz. to 16 oz.
Pres.—Chris Haas

★*Cadillac Plastic & Chemical Co., Detroit (E)
Extrusion machines: 1–1¼″, 3–1¾″, 1–2″, 3–3″, 1–4″
Pres.—Robert B. Jacob
Exec. Vice Pres.—Richard J. Jacob
Sls. Mgr.—Lloyd R. Marentette
Pur. Agt.—Frank Barnard

★Detroit Macoid Corp., Detroit (E, I)
Extrusion machines: 16
Injection machines: 12
Pres.—Geo. S. Hendrie, Sr.
Vice Pres. & Pur. Agt.—J. E. Gould
Sls. Mgr.—S. D. Bradley

★Detroit Plastic Products Co., Mt. Clemens (I)
Injection machines: 2–4/6 oz.; 5–12/16 oz.; 1–20 oz.

*Double D Plastics, Greenville (I)
Injection machines: 1–4 oz.; 1–6 oz.; 3–8 oz.; 2–20 oz. to 28 oz.; 1–32 oz.
Pres.—Earl D. Drake
Gen. Mgr.—C. N. Wilson
Sls. Mgr.—K. G. Aylsworth
Pur. Agt.—John S. Clark

Duralastic Products Co., Detroit (C)
Compression presses: 27–30 ton to 200 ton
Pres.—Joseph N. Epel
Vice Pres.—Julius Barach
Sls. Mgr. & Project Engineer—Clyde J. Hamner
Pur. Agt.—James R. Pollock

★Fabricon Products, Inc., River Rouge (C)
Compression presses: 15 ton to 200 ton
Pres.—L. A. Fisher
Asst. to Pres.—C. L. Keller
Sls. Mgrs.—J. T. Galvin, R. C. Fontham, C. E. Feltner
Pur. Agt.—G. Barber

*Frank Plastics Corp., Detroit (E)
Extrusion machines: 3

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* Operates own tool room
★ Indicates Advertiser

*General Machine & Tool Works, Walled Lake (C, I)
Compression presses: 2–150 tons
Injection machines: 1–4 oz., 4–8 oz., 4–32 oz., 1–60 oz., 1–48/80, 1–80/120, 1–300 oz., 1–400 oz.

General Plastics, Inc., Kalamazoo (E, I)
Extrusion machines: 1–2½"
Injection machines: 1–2 oz.; 1–2½ oz.; 1–8 oz.; 1–12 oz.
Pres., Sales Mgr., and Pur. Agt.–M. K. Gibson
Vice Pres.–Al Belrose

Grand Haven Plastics Co., Grand Haven (C)
Compression presses: 6–From 25 ton to 150 ton

Hoffman Industries, Inc., Spring Arbor (I)
Injection machines: 1–4 oz.; 1–3 oz.; 1–12 oz., 1–16 oz.
Pres.–John J. Hoffman
Vice Pres. & Sls. Mgr.–Eugene F. Hoffman
Pur. Agt.–William P. Hoffman

*Hughes Plastics Inc., St. Joseph (I)
Injection machines: 3–4 oz.; 1–9 oz.
Pres.–Kent H. Hughes
Sls. Mgr.–R. S. Kasischke

*Kal Plastics, Inc., Beaverton (E)
Pres.–M. J. Kalahar
Sls. Mgr.–Rod Tawsley

*Lus-Trus Corp., Ypsilanti, (E)
Extrusion machines: 10–from 2" to 3½"
Pres., Pur. Agt.–Eldon E. Magnuson
Vice Pres.–Fred N. Blackmore
Sls. Mgr.–Fred E. Schwab

*MacDonald Mfg. Co., New Baltimore (C, I)
Compression presses: 2–150 ton
Injection machines: 1–3 oz.; 1–4 oz.; 4–8 oz.; 1–9 oz.; 1–20 oz.; 1–22 oz.; 1–32 oz.; 1–48 oz.; 2–64 oz.
Pres.–Stuart MacDonald
Plant Mgr.–Scott Walker
Pur. Agt.–Donald Morrish

★Michigan Plastic Products, Inc., Grand Haven (I)
Injection machines: 1–4 oz.; 1–6 oz.; 2–8 oz.; 2–16 oz.; 2–20 oz.; 1–32 oz.
Pres., Sales Mgr.–Miller G. Sherwood
Vice Pres.–Marion A. Sherwood
Pur. Agt.–Mary Bosman

*Mitchell Plastics, Inc., Owosso (I)
Injection machines: 2–4 oz.; 2–6 oz.; 2–8 oz. 1–12 oz.; 3–16 oz.; 1–32 oz.; 1–48 oz.
Pres.–William F. Mitchell
Vice Pres., Gen. Mgr.–Henry L. Miller
Vice Pres., Sls. Mgr.–Thomas S. Drabek
Pur. Agt.–G. A. Van Epps

*Modern Plastics Corp., Benton Harbor (C, I, T)
Compression presses: 35–35 ton to 1200 ton
Injection machines: 21–4 oz. to 60 oz.
Transfer presses: 25–35 ton to 500 ton
Pres.–Victor A. Miller
Vice Pres., Gen Mgr.,–Owen E. Skelton
Pur. Agt.–Richard Smikle

Pace Co., F. D., Grand Rapids (C, I)
Compression presses: 1–30 ton
Injection machines: 1–1 oz.
Pres., Sls. Mgr.–F. D. Pace
Vice Pres.–J. A. Pace
Pur. Agt.–L. Vanderbrink

Plastic Masters, Inc., New Buffalo (C, I)
Compression presses: 2–730 ton; 1–600 ton; 2–230 ton, 3–175 ton; 2–150 ton, 1–125 ton; 1–45 ton
Injection machines: 3–20 oz.; 3–12 oz.
Pres.–Victor A. Miller
Vice Pres.–Owen E. Shelton
Sls. Mgr.–Carl G. Marquardt
Pur. Agt.–Bernard A. Guerrattaz

Plastray Corp., Walled Lake (I)
Injection machines: 9–4 to 24 oz.
Pres. & Sls. Mgr.–D. L. Jocelyn
Vice Pres.–H. V. Mutter
Pur. Agt.–R. J. Granlund

Reynolds Plastics, Inc., Walled Lake (C)
Compression presses: 1–8 ton; 1–100 ton
Pres.–George Kouvacs
Vice Pres.–J. Kouvacs
Sls. Mgr. Pur. Agt.–H. Bill Bem

*Robbins, Jim, Co., Royal Oak (I)
Injection machines: 8–4 oz.; 2–8 oz.; 1–12 oz.; 8–16 oz.; 18–20 oz.; 2–60 oz., 1–100 oz.
Pres.–J. M. Robbins
Exec. Vice Pres., Sls. Mgr.–W. L. Johnson
Exec. Vice Pres.–H. G. Michael
Pur. Agt.–C. W. Cornwall

St. Clair Plastics Corp., Marine City (E)
Injection machines: 1–4 oz.; 1–4 oz. to 6 oz.; 1–8 oz.; 1–10 oz.; 1-12 oz. to 16 oz.
Pres., Pur. Agt.–A. Kindsvater

*St. Regis Paper Co., Michigan Panelyte Molded Plastics Div., Dexter (C, I, T)
Compression presses: 2–30 ton; 1–35 ton; 7–50 ton; 5–100 ton; 5–150 ton; 8–200 ton; 1–300 ton; 1–400 ton; 1–500 ton
Injection machines: 1–4 oz.; 1–6 oz.; 2–8 oz.; 1–10 oz.; 4–12 oz.; 4–16 oz.; 2–48 oz.
Transfer presses: 5–200 ton; 1–300 ton
Plant Mgr.–Paul Y. Chamberlin
Sls. Mgr.–E. E. Sanders
Pur. Agt.–Walter K. McGee
Chief Sls. Engineer–W. J. Parsons

Swedish Crucible Steel Co., Detroit (C, E, I)
Compression presses: 45–100 to 500 ton
Extrusion machines: 5–2½" to 3½"
Injection machines: 12–8 oz. to 80 oz.
Pres.–O. L. Olson
Pur. Agt.–J. Efrusy

★Thierica Studio, Inc., Grand Rapids (I)
Injection machines: 2–up to 16 oz.

*W-L Molding Co., The, Kalamazoo (C, I, T)
Compression presses: 1-20 ton; 1–30 ton; 2–100 ton; 1–200 ton; 2–250 ton
Injection machines: 2–6 oz.; 3–8 oz.; 1–12 oz.; 2–20 oz.
Transfer presses: 1–30 ton; 1–100 ton; 2–250 ton; 1–20 ton
Pres., Sls. Mgr.–Geo. R. Laure
Vice Pres.–E. L. Laure
Pur. Agt.–J. P. Nielsen

Wolverine Plastics, Inc., Milan (I)
Injection machines: 14–6 oz. to 140 oz.
Pres., Sls. Mgr.–Dan Vass
Vice Pres. Eng.–Jay Kuhn
Pur. Agt.–Don Harkness

*Woodall Industries, Inc., Detroit (C, E)
Compression presses: 28–up to 1000 ton
Extrusion machines: up to 6"
Pres.–H. J. Woodall
Exec. Vice Pres.–C. B. Johnson
Sls. Mgr.–A. J. McKeon, Jr.
Pur. Agt.–G. K. Geisbuhler

MINNESOTA

*Booker & Wallestad, Inc., Minneapolis (I)
Injection machines: 1–1 oz.; 1–4 oz.; 15–2 oz.
Pres.–R. G. Booker
Vice Pres.–V. C. Wallestad
Sales Mgr.–R. J. Lindgren
Pur. Agt.–Donald Peoples

*Contour Plastic Molding, Inc., Minneapolis (I)
Injection machines: 6–½ oz; 2–2 oz.; 3–2½ oz.; 1–4 oz.; 1–12 oz.

Engineering Associated, Winona (I)
Injection machines: 1–2 oz.; 1–4 oz.; 1–3 oz.
Gen. Mgr.–Basil W. Leggin

*Mayon Plastics, Hopkins (E)
Extrusion machines: 3–2½"; 1–3½"
Gen. Mgr. & Pur. Agt.–Ray D. Johnson

Minneapolis Plastic Molders, Inc., Minneapolis (C, I, T)
Compression presses: 18–50 ton to 300 ton
Injection machines: 4–2 oz. to 8 oz.
Transfer presses: 10–50 ton to 300 ton
Pres., Treas.–J. Erick Anderson

★*Minnesota Plastics Corp., St. Paul (I)
Injection machines: 29–2 oz. to 80 oz.
Pres.–H. R. Galloway
Vice Pres.–C. S. Blackwell
Sales Mgr.–J. H. Thomas
Pur. Agt.–N. A. Sandven

*North Star Industries, Hopkins (I)
Injection machines: 1–4 oz. 1–6 oz.
Pres. & Sls. Mgr.–Ray H. Harris
Vice Pres.–Leo B. Harris
Pur. Agt.–Frank Harris

★Northwest Plastics, Inc., St. Paul (C, I, T)
Compression presses: 20–50 to 500 tons
Injection machines: 14–2–24 oz.
Transfer presses: 16–150 to 500 tons

*Plastics, Inc., St. Paul (C, I, T)
Compression presses: 18–12 to 500 ton
Injection machines: 5–2 oz. to 24 oz.
Transfer presses: 4–from 175 ton to 500 ton
Pres.–H. A. Briebenow
Vice Pres., Sls. Mgr.–P. K. Schilling
Pur. Agt.–M. Peterson

*Products Engineering & Development Co., Hopkins (C, T)
Compression presses: 2–175 ton, 1–100 ton, 1–30 ton
Transfer presses: 1 plunger transfer, 175 ton
Sls. Mgr., Pur. Agt.–A. G. Morrison

*Rainbow Plastic Products, Inc., Minneapolis (I)
Injection machines: 5–from 2½ oz. to 20 oz.
Pres.–L. E. Erickson
Vice Pres.–O. A. Hultgren

*Rayette, Inc., St. Paul (C, I)
Compression presses: 1–15 ton; 2–30 ton; 2–50 ton; 3–100 ton; 1–150 ton; 1–200 ton
Injection machines: 2–8 oz.; 1–4 oz.
Pres.–M. L. Arend
Vice Pres.–W. P. Niemiec
Sls. Mgr.–D. F. Boyd
Pur. Agt.–Elizabeth Houston

*Sperzel Co., Minneapolis (C, I, T)
Compression presses: 1–400 ton; 3–600 ton; 4–1500 ton
Injection machines: 1–4 oz. to 6 oz.; 1–8 oz. to 10 oz.; 8–12 oz. to 16 oz.
Transfer presses: 1–400 ton; 3–600 ton
Pres., Pur. Agt.–M. J. McCabe
Vice Pres., Sls. Mgr.–H. H. Reinhard

*Thermotech Plastics, Inc., Affiliate of Booker & Wallestad, Inc., Minneapolis (C, I)
Compression presses: 1–25 ton; 1–30 ton; 2–50 ton; 1–75 ton
Injection machines: 4–2½
Pres., Sls. Mgr.–E. M. Booker
Vice Pres.–J. M. Thomson

*Thunderbird Plastics, Inc., Minneapolis (I)
Injection machines: 1–6 oz.; 1–8 oz.; 1–9 oz.; 4–12 oz. to 16 oz.

*United Fabricators & Electronics, Inc., Stillwater (I)
Injection machines: 4–1 oz.; 3–2½ oz.
Pres., Sls. Mgr.–R. C. Gilbert
Vice Pres.–Albert Kreimer
Pur. Agt.–F. R. Gilbert

*Wilcox Products Co., Minneapolis (I)
Injection machines: 3–2 oz.; 2–2½ oz.; 1–4 oz.; 1–6 oz.
Pres.–Earl W. Nelson
Vice Pres.–Sylvester Mady

MISSOURI

*Cepco Plastics Co., (Crestwood) St. Louis (I)
Injection machines: 1–4 oz.; 1–6 oz.; 1–16 oz.; 1–80 oz.
Pres.–R. A. Karasek
Vice Pres.–Frederick Taussig
Pur. Agt.–Dave Tanner

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* Operates own tool room
★ Indicates Advertiser

Clear View Plastics Corp., Poplar Bluff (C, I)
Compression presses: 2–12 oz; 2–12 oz. to 16 oz. 1–16 oz. to 20 oz.
Pres., Sls. Mgr.—Earl Baumgardner

Engineered Products, Inc., Hazelwood (I)
Injection machines: 1–6.; 1–8 oz.; 1–10 oz.; 1–12 oz.; 1–16 oz.
Pres.—George R. Krieger
Vice Pres. & Treas.—Roger C. Shirtum
Gen. Mgr. & Pur. Agt.—Leon E. Lada

Hanley Plastics Co., St. Louis (C, I)
Pres.—A. J. Spanogle

***Howard Moldings Inc.,** Kansas City (C)
Compression presses: 2–150 tons; 1–100 tons; 2–50 tons, 4–100 tons; 1–315 tons; 1–15 tons.
Pres.—James P. Kay
Vice-Pres.—Jack R. Kay
Sls. Mgr.—Robert L. Langford
Pur. Agt.—Larry A. Miller

***Injection Molding Co.,** Kansas City (C, E, I, T)
Pres.—W. K. Archer
Vice Pres.—M. L. Davis., M. J. Grebowiec
Exec. Vice-Pres. & Sls. Mgr.—R. V. Vosburgh
Pur. Agt.—E. M. Davis

***Koller Craft Plastic Products, Inc.,** Fenton (C, I, T)
Compression presses: 2–50 tons; 2–100 tons; 3–150 tons; 2–200 tons; 1–250 tons; 1–300 tons.
Injection machines: 1–300 oz.; 1–200 oz.; 1–100 oz.; 2–32 oz.; 1–23 oz.; 3–20 oz.; 2–16 oz.; 1–9 oz.; 1–12 oz. 3–4 oz.; 1–2 oz.
Transfer presses: 1–300 tons; 3–175 tons, 1–125 tons.
Pres.—A. J. Koller
Pur. Agt.—R. Boehner

***Kuhlman Plastics Co., Inc.,** Kansas City (I)
Injection machines: 1–4 oz.; 1–9 oz.; 2–12 oz.; 4–16 oz.; 1–20 oz.; 2–48 oz; 1–60 oz.
Pres.-Sls. Mgr. & Pur. Agt.—O. E. Kuhlman
Vice Pres. & Pur. Agt.—Mrs. Marie Kuhlman

Lenco, Inc., Jackson (C, I, T)
Compression presses: 1–75 ton; 1–100 ton; 1–200 ton
Injection machines: 1–8 oz.
Transfer presses: 1–200 ton
Pres.—Paul J. Leonard
Vice Pres.—W. C. Martinson
Sls. Mgr. & Pur. Agt.—A. E. Perrin

***Plastics Molding Co., Inc.,** St. Louis (C, I, T)
Compression presses: 5–75 ton, 5–100 ton, 10–175 ton
Injection machines: 1–4 to 6 oz.
Transfer presses: 5–75 ton, 5–100 ton, 10–175 ton
Pres.—William Bachman
Vice Pres.—Harold Bachman
Sls. Mgr.—R. S. McDomman

***St. Louis Plastic Moulding Co.,** St. Louis (I)
Injection machines: 7
Pres.—G. A. Goessling
Vice Pres.—Val J. Goessling
Pur. Agt. L. R. Sappington

NEBRASKA

***Kerrco Products,** Lincoln (C, I, T)
Compression presses: 7–50-200 tons
Injection machines: 4–3 oz. to 12 oz.
Transfer presses: 2
Pres.—R. W. Kerr
Sls. Mgr.—D. W. Hemphill

Omaha Plastics Co., Omaha (C, I,T)
Compression presses: 4–25 to 325 tons
Injection machines: 2–1 to 4 oz.
Transfer presses: 1–350 ton
Pres. & Pur. Agt.—George D. Kahn
Vice Pres.—Jewel K. Kahn

***Western Plastics Corp.,** Hastings (E)
Extrusion machines: 8–1" to 3½"
Pres., Treas.—John J. Lainson
Vice Pres.—H. A. Lainson
Asst. Sls. Mgr.—Larry D. Schnase
Pur. Agt.—Keith W. Nielsen

NEW JERSEY

***Action Plastics, Inc.,** Paterson (E)
Extrusion machines: 4–4½"; 2–3½"; 4–2½"; 2–1½"
Pres.—Milton Weiss
Vice Pres.—Jules R. Bessermann, Peter H. Seckel

All Plastics Corp., Avon-By-The-Sea (I)
Injection machines: 2–4 oz. to 6 oz.; 1–8 oz., 1–12 oz. to 16 oz.
Pres.—Albert C. Tompkins
Vice Pres., Sls. Mgr., Pur. Agt.—William B. Tompkins

***American Hard Rubber Co., Div of Amerace Corp.,** Butler (C, E, I, T)
Compression presses: 16–100 ton; 16–175 ton; 30–200 ton; 39–250 ton; 3–380 ton; 1–400 ton; 2–500 ton; 1–760 ton; 3–1600 ton; 1–2400 ton
Extrusion machines: 10–2¼" to 4½"
Injection machines: 1–1 oz.; 8–8 oz.; 1–48 oz.
Transfer presses: 1–500 ton
Pres.—N. Tuthill
Vice Pres.—R. Reppert
Sls. Mgr.—G. H. Reed
Pur. Agt.—V. Culver

Arrow Plastics Corp., Passaic (I)
Injection machines: 6: 1–4 oz.; 3–12 oz.; 1–12 to 16 oz.; 1–24 oz.

***Atlas Plastics, Inc.,** Little Ferry (I)
Injection machines: 3–12 oz.; 1–5 oz.
Pres., Sls. Mgr., Pur. Agt.—B. W. Maute

Berkeley Engineering & Mfg. Co., Berkeley Heights (C, I)
Compression presses: 1–50 ton; 1–150 ton
Injection machines: 2–4 oz. 1–oz.; 1–16 oz.
Partner, Gen. Mgr., Sls. Mgr., Alfred F. Bahlke
Partner, Factory Supt.—William Giese
Pur. Agt.—Arthur F. Paulina

***Bloomfield Molding Co.,** Bloomfield (C, I)
Compression presses: 3–100 ton; 3–200 ton; 2–300 ton
Injection machines: 1–4/6 oz.; 5–12/16 oz.; 1–8/10 oz.; 1–4 oz.; 1–16 oz.; 1–20 oz.
Pres.—Sam Novick
Sales Mgr.—A. Lewis
Pur. Agt.—J. L. Verner

***Boonton Molding Co.,** Boonton (C, I, T)
Compression presses: 96–from 25 ton to 500 ton
Injection machines: 19–from 2 oz. to 16 oz.
Transfer presses: 17–from 25 ton to 300 ton
Sls. Mgr.—Chris. J. Groos
Pur. Agt.—Henry E. Packer

Britel Products, Inc., Paterson (I)
Injection machines: 6–2 oz. to 12 oz.
Pres.—G. A. Brightman III

***Carolan & Co., Inc., K. T.,** Orange (E)
Extrusion machines: 3–1"; 1½"; 3"
Pres., Sales Mgr.—Kenneth T. Carolan
Vice Pres.—H. J. O'Gorman

***Celluplastic Corp.,** Newark (E, I)
Extrusion machines: 5–up to 3½"
Injection machines: 16–3 oz. to 22 oz.
Pres., Treas.—J. D. Giles
Vice Pres., Sales—J. D. Proctor
Vice Pres., Prod.—A. Nichols

***Claremould Plastics Co.,** Newark (I)
Injection machines: 10–from 4 oz. to 16 oz.
Pres., Secy., Pur. Agt.—Philip Clare
Vice Pres., Sls. Mgr.—George Clare

***Corroplast, Inc.,** Passaic (E)
Vice Pres.—W. A. Mollard
Sls. Mgr., Pur. Agt.—Jacob Jaglom

★***Davis Plastics Co., Joseph,** Kearny (E, I)
Extrusion machines: 26–1" to 8"
Injection machines: 14–2 to 16 oz.
Pres.—Morton Davis
Vice Pres.—Abe Davis
Sls. Mgr.—Stanley Shur
Pur. Agt.—S. Goldblatt

***Desimone Corp., A. J.,** East Paterson (I)
Injection machines: 18: 2–12"; 3–16"; 13–8"
Pres.—A. J. Desimone
Vice Pres. & Pur. Agt.—J. A. Desimone
Sls. Mgr.—Stanley O. Fenkel

★***Dillon-Beck Mfg. Co.,** Hillside (I)
Injection machines: 1–8 oz.; 4–4 to 6 oz. 5–12 to 16 oz.
Pres.—J. Parke Logan
Vice Pres., Sls.—Charles B. Sanders
Vice Pres., Production—Richard R. Lowe
Pur. Agt.—R. C. Ellis

★**Emeloid Co., Inc., The,** Hillside (I)
Injection machines: 2–2 oz.; 2–4 oz.; 2–6 oz.; 2–8 oz.; 1–12 oz.
Pres.—M. P. Leeds
Vice Pres.—J. S. Freundlich
Sales Mgr.—G. W. Emerson
Pur. Agt.—Florence Headley

***Fibro Corp.,** Clark (I)
Injection machines: 13: 1–1 oz.; 3–6 oz. to 8 oz.; 2–9 oz.; 1–12 to 16 oz.; 3–16 oz.; 2–20 oz.; 1–48 oz.
Pres.—Frank Fontenelli
Vice Pres. & Sls. Mgr.—John Fontenelli
Pur. Agt.—Richard K. Searles

Food Film, Inc., Caldwell Township (E)
Extrusion machines: 3–1½"; 1–2½"
Pres.—M. R. Gerow
Vice Pres.—L. S. Little
Pur. Agt.—D. D. Gerow

***Fortney Mfg. Co., Inc.,** Newark (I)
Injection machines: 1–4 oz.; 3–8 oz.; 1–12 oz.
Pres. & Sls. Mgr.—Eugene L. Fortney
Pur. Agt.—Elias L. Egeth

★***Garfield Mfg. Co.,** Wallington (C, T, CM)
Compression presses: 7–25 ton, 5–50 ton, 4–100 ton, 1–200 ton, 1–300 ton, 1–500 ton.
Transfer presses: 1–25 ton, 1–50 ton, 4–100 ton, 1–200 ton, 1–300 ton
Pres.—F. W. Bauer
Sls. Mgr.—John Klimock
Pur. Agt.—H. E. Sheard

***Garray Plastics, Inc.,** Kearny (I)
Injection machines: 8–2 oz. to 16 oz.
Pres.—Joseph Charzewski
Vice Pres.—Henry Charzewski
Sales Mgr.—Robert Young
Pur. Agt.—Doris McCracken

***Gibson Associates, Inc.,** Cranford (I)
Injection machines: 1–4 oz. to 6 oz.; 18–12 oz. to 16 oz.
Pres.—Royal H. Gibson
Vice Pres.—Eleanor McIlvaine
Sales Mgr.—Frank J. Daleo
Pur. Agt.—Anthony J. Grimaldi

***Greising Engineering Co.,** Runnemede (C, I)
Compression presses: 8–10 ton to 100 ton
Injection machines: 1–2 oz.
Pres.—A. R. Greising
Pur. Agt.—I. R. Greising

Holstein, Lee, Injection Molding, Inc., Clifton (I)
Injection machines: 1–4 oz.; 1–6 oz.; 1–8 oz.; 1–12 oz.
Pres.—Lee Holstein
Vice Pres.—Selma Holstein

***Hungerford Plastics Corp.,** Morristown (E, I)
Extrusion machines: 5-1½" to 6"
Injection machines: 15–3 oz. to 32 oz.
Pres.—D. C. Hungerford
Sls. Mgr.—D. P. Arrowsmith
Pur. Agt.—R. V. Jacques

***Hyde Co., A. L.** Grenloch (E, I)
Extrusion machines: 3–2"; 12–2 oz. to 200 oz.
Pres. & Sls. Mgr.—A. S. Hyde
Vice Pres.—C. L. Hyde
Pur. Agt.—A. L. Hyde

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* Operates own tool room
★ Indicates Advertiser

***Hydrawlik**, Roselle (E,I)
Extrusion machines: 1–3¼"; 1–4"
Injection machines: 1–8 oz.
Pres. & Sales Mgr.–George A. Brown
Pur. Agt.–M. M. Johnson

***Industrial Devices Inc.**, Edgewater (I)
Injection machines: 5–2½ oz.
Pres.–Nathan Schnoll
Vice Pres. & Sls. Mgr.–N. J. Seiden
Pur. Agt.–G. E. Mesnick

Industrial Plastic Co., Metuchen (E)
Extrusion machines: 6–1" to 4½"
Pres. & Pur. Agt.–Edgar A. Baurer
Sls. Mgr. & Vice Pres.–Joseph Schenkman

***Keystone Plastics Inc.**, Newark (E, I)
Extrusion machines: 1–2"; 2–2½"; 2–3¼"
Injection machines: 3–2 oz.
Pres.–William Gould
Vice–Pres.–Charma Gould

★***Killion Tool & Mfg. Co.**, Verona (E)
Extrusion machines: 4
Pres.–Fred T. Killion

★***Kuhn & Jacob Molding & Tool Co.**, Trenton (C, T)
Compression presses: 5–100 ton; 6–60 ton; 3–35 ton; 6–25 ton
Transfer presses: 2–320 ton; 2–200 ton; 10-140 ton; 14–100 ton; 20–50 ton automatics
Pres.–Eugene Jacob
Vice Pres.–Walter Jacob
Sls. Mgr.–Walter Jacob, Jr.
Pur. Agt.–Michael King

Laurel Plastics Inc., Asbury Park (I)
Injection machines: 9–3 oz. to 8 oz.
Pres.–David J. Rosenheim
Vice Pres.–Marcelle Rosenheim
Pur. Agt.–Stacey Tavis

★***Lor-El Co.**, Jersey City (I)
Injection machines: 1–1 oz.; 4–4 oz.; 4–5 oz.; 1–6 oz.; 1–12 oz.; 1–20 oz.
Pres., Sls. Mgr., Pur. Agt.–Lore E. Feiler
Vice. Pres.–E. J. Angelica

***Luzerne Rubber Co.**, Trenton (C, E, I)
Compression presses: 12–80 ton; 5–150 ton; 5–200 ton; 2–600 ton
Extrusion machines: 1–4½"
Injection machines: 2–5 to 7 oz.
Pres.–Bruce Bedford, Jr.
Vice Pres.–Harry E. Case
Sls. Mgr.–M. J. Kearney, Jr.
Pur. Agt.–Wm. Gummere

M.C.I. Plastics Corp., Lakewood (I)
Injection machines: 3–4/6 oz.; 4–12/16 oz.

***Mack Molding Co.**, Wayne (C, E, I, T)
Compression Presses: 45–15 ton to 560 ton
Extrusion Machines: 2
Injection Machines: 67–½ oz. to 560 oz.
Transfer Presses: 12–90 ton to 560 ton
Pres.–D. S. Kendall
Vice Pres.–J. McIntosh
Sls. Mgr., Secy.–S. I. Howell
Pur. Agt.–R. Marx, E. Smith

***Madan Plastics, Inc.**, Cranford (C,I)
Compression presses: 1–250 ton; 1–350 ton
Injection machines: 3–2 oz.; 1–6 oz.; 2–16 oz.; 1–24 oz.; 1–42 oz.
Pres., Sales Mgr.–R. W. Madan
Sec.-Treas.–E. K. Madan
Chief Eng.–L. W. Jordan
Plant Mgr.–A. Kwiecien
Pur. Agt.–S. Miller

***Martindell Molding Co.**, Trenton (C, I, T)
Compression presses: 19–59 ton to 300 ton
Injection machines: 5–4 oz. to 16 oz.
Transfer presses: 12–100 ton to 300 ton
Pres.–A. S. Martindell
Vice Pres. & Sales Mgr.–G. C. Zentmayer
Sec.-Treas.–M. H. Martindell, Jr.
Pur. Agt.–J. C. Smith

McCormack Rubber Co., Ridgefield (C)
Compression presses: 19–25 ton to 400 ton
Pres., Sls. Mgr.–Robert J. Heiney
Vice Pres.–I. Gralnick
Pur. Agt.–M. Kearns

Mira Plastics Co., Inc., Paterson (I)
Injection machines: 7–2 oz. to 20 oz.

Modern Molders, Inc., Kenilworth (I)
Injection machines: 4–16 oz.
Pres.–Michael Lutz
Pur. Agt.–Charles G. Karross Jr.

Modular Molding Corp., Burlington (C)
Compression Presses: 1–100 ton
Pres.–A. R. Pollack
Plant Mgr.–W. A. Steene
Pur. Agt.–P. A. Tamny

Natvar Corp., Woodbridge (E)
Extrusion machines: 12
Pres.–Frederick M. Damitz
Vice Pres.–S. Sichermann
Sls. Mgr.–S. Sichermann
Pur. Agt.–M. N. Hilseberg

★***Orange Products, Inc.**, Orange (I)
Injection machines: 1–4-6 oz.; 3–8 oz.
Pres.–L. W. Schaper
Vice Pres.–C. J. Gentile

***Park Plastics Co.**, Linden (I)
Injection machines: 2–3 oz.; 6–6 oz.; 13–12 oz.; 1–24 oz.
Pres.–A. Lange
Vice Pres.–E. Joffe
Pur. Agt.–A Monte

Plastex Process Co., Maywood (E)
Extrusion machines: 1–1½", 1–2½"
Pres., Sls. Mgr.–Clifford Jordan
Vice Pres., Pur. Agt.–Russel Jordan

***Plastic Extruded Products Co.**, Elizabeth (E)
Extrusion machines: Up to 3½"
Sls. Mgr.–John G. Walsh
Pur. Agt.–George J. Katelus

***Plastic Inlays, Inc.**, Summit (I)
Injection machines: 4–8 oz.; 3–4 oz.
Pres.–J. J. Larmour
Sls. Mgr.–O. M. Stanley
Pur. Agt.–C. B. Brown

***Plastic Laminating Corp.**, Vauxhall (C)
Compression presses: 2–24 x 26 300 ton; 1–24 x 54 500 ton; 1–36 x 43 500 ton
Pres., Sls. Mgr.–Joseph DiBella
Vice Pres.–Vincent T. Cooney
Pur. Agt.–Terry Kane

***Plasticraft Manufacturing Co.**, Kearny (I)
Injection machines: 4–16 oz.
Pres.–I. Siper
Vice Pres., Sls. Mgr.–Ben Siper
Pur. Agt.–Sam Siper

Plastylite Corp., North Plainfield (C, E, T)
Compression presses: 16–50 to 250 ton
Extrusion machines: 2–2½"
Transfer presses: 3–100-250 ton
Pres.–H. Weinraub
Vice Pres. & Sls. Mgr.–Robert J. Goldstein
Pur. Agt.–R. Angelo

***Plura Plastics**, Maplewood (I)
Injection machines: 3–8 oz.; 1–2 oz.

Poly Plastic Products, Inc., Paterson (E)
Extrusion machines: 7, 1½" to 4½"
Pres., Sls. Mgr.–Joseph Esak
Vice Pres., Pur. Agt.–Alfred A. Voskian

Polyplastex United, Inc., Union (C)
Compression presses: 1-10 openings, 3" daylight, 48" x 96"; 1-10 openings, 3" daylight, 3½" x 3½"
Pres.–H. W. E. Riley
Vice Pres.–A. W. Ehlers, S. F. Peskin
Sls. Mgr.–J. L. Shafer
Pur. Agt.–M. Carbo

★***Pyro Plastic Corp.**, Union (I)
Injection machines: 40 automatic from 2 to 12 oz.
Pres.–William M. Lester
Sls. Mgr.–Paul H. Schaaf, Jr.
Pur. Agt.–Louis Lubars

***Reliance Plastic & Chemical Corp.**, Paterson (E)
Extrusion machines: 3
Pres.–Fred Levin
Sls. Mgr.–J. R. Gordon

Resistoflex Corp., Roseland (C, E)
Compression presses: 12–presses up to 1200 ton
Extrusion machines: 10
Pres.–E. S. Peierls
Vice Pres.–H. E. Krebs
Sls. Mgr.–H. H. Wulff
Pur. Agt.–R. Atkins

Richard Alan Button Co., Roosevelt (C, I, T)
Compression presses: 1–30 ton; 1–50 ton; 12–150-200 ton
Injection machines: 1-2 oz.
Transfer presses: 1–200 ton
Pres.–B. S. Haines
Plant Engineer–H. E. Melvin
Pur. Agt.–N. Richter

Sanford Plastics Corp., Matawan (C, E, I)
Compression presses: 2–150 ton
Extrusion machines: 5–from 1" to 2½"
Injection machines: 1–3 oz.
Pres.–Warren L. Schnur
Vice Pres.–John B. Anderson
Pur. Agt.–Sanford J. Emil

***Shasta Mfg. Co.**, Berkeley Heights (C, I, T)
Compression and transfer presses: 7–75 ton to 350 ton
Injection machines: 7–2 oz. to 20 oz.
Gen. Mgr.–G. S. Sullivan

Shaw Insulator Co., Irvington (C, I, T)
Compression and transfer presses: 45–from 15 ton to 400 ton
Injection machines: 7–2 oz. to 24 oz.
Pres.–Frank H. Shaw
Vice Pres.–Stanford H. Shaw
Sls. Mgr.–Joe R. Brown
Pur. Agt.–Frank P. Ashley

***Springfield Tool & Die Co., Inc.**, Springfield (I)
Injection machines: 1–6 oz., 4–12 oz., 1–24 oz.
Pres., Mgr.–Ludwig Stark

Star Mfg., Inc., Little Ferry (C, T)
Compression presses: 15–15 to 300 tons
Transfer presses: 10–15 to 300 tons
Pres.–Frank Vecchiotti
Vice Pres.–Vincent Vecchiotti

***Sterling Plastics Co.**, Union (I)
Injection machines: 12–2 to 20 oz.
Pres.–George J. Staab
Sls. Mgr.–Charles A. Cox
Pur. Agt.–F. E. Betz

***Sussex Plastics Co.**, Belleville (E)
Extrusion machines: 1–3½", 2–2½", 3–1½"
Mgr.–Willy Eckert
Sls. Mgr.–John H. Strasbourger

***Swenson, V. H., Co., Inc.**, Kearny (C, I)
Compression presses: 1–50 ton, 1–150 ton
Injection machines: 12–4 to 12 oz.
Pres., Sls. Mgr.–V. H. Swenson
Vice Pres.–G. I. Feeley
Pur. Agt.–G. I. Feeley

***Tech-Art Plastics Co.**, Morristown (C, I, T)
Compression presses: 80–50-1000 ton
Injection machines: 8–2 to 20 oz.
Transfer presses: 6–50 to 200 ton
Pres. & Treas.–Harold J. Cook
Vice Pres.–John P. Lombardi
Sls. Mgr.–William J. Woodruff
Pur. Agt.–Michael Halabura

★***Thermoplastic Processes, Inc.**, Stirling (E)
Extrusion machines: 4–1¼" (vertical); 2–1½"; 6–2½"; 1–3½"; 2–4½"
Pres.–James H. Du Pont

***Thomas Mfg. Corp.**, Newark (I)
Injection machines: 12–2 oz. to 8 oz.
Pres.–Islyn Thomas
Vice Pres.–Kasper Staub
Sls. Mgr.–Fred Bovais
Pur. Agt.–William Williams

Van Ness Plastic Molding Co., Belleville (I)
Injection machines: 3: 6 oz. and 8 oz.
Pres., Sls. Mgr., Pur. Agt.–Paul J. Van Ness
Vice Pres.–Mrs. Paul J. Van Ness

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* Operates own tool room
★ Indicates Advertiser

***Wagner Plastic Corp.,** Lakewood (I)
Injection machines: 5
Pres.—Walter Wagner
Vice Pres.—Lester Myers

***Wiggins Plastic Molding Co.,** Clifton (C, I, T)
Compression presses: 15—10 ton to 565 ton
Injection machines: 6—1 oz. to 8 oz.
Transfer presses: 15—20 ton to 565 ton
Pres.—Jack Wiggins
Sls. Mgr.—G. Kaiserano
Pur. Agt.—A. J. Wiggins

***Wilpet Tool & Mfg. Co.,** Kearny (I)
Injection machines: 22—2 oz. to 16 oz.
Pres., Sls. Mgr.—William L. Niclaus
Vice Pres., Pur. Agt.—Richard Niclaus

***Young Development Div., Explosives Dept., Hercules Powder Co.,** Rocky Hill (C, E)
Compression presses: 2—10 ton; 1—30 ton; 1—50 ton; 1—150 ton
Extrusion machines: 2
Dir.—Richard E. Young
Exec. Asst.—Harry Tipper
Contracts Admn.—Douglas M. Clarke
Plant Supt.—Wallace J. Cullen

NEW YORK

***A.A.A. Plastic Co.,** New York (C, E, I)
Compression presses: 8—500 ton to 2000 ton
Extrusion machines: 5—1½" to 4"
Injection machines: 6—2 oz. to 16 oz.
Pres., Sales Mgr.—L. H. Posner
Vice Pres.—S. Posner
Pur. Agt.—Thomas Logan

***Aacon Industries, Inc.,** Brooklyn (E, I)
Extrusion machines: 2—48" width flat sheeting; 8" x 12" cube extrusion maximum
Injection machines: 1—2 oz., 1—6 oz., 1—16 oz.
Pres.—Harry San
Plant Engr.—L. Furst
Sls. Mgr.—L. Goldberg
Pur. Agt.—Paul Richards

Accurate Molding Corp., Long Island City (C, T)
Compression presses: 16—15 ton to 300 ton
Transfer presses: 2—150 ton
Pres., Sales Mgr.—Leo Adenbaum
Vice Pres.—David Adenbaum
Pur. Agt.—Alex Adenbaum

★*Ace Plastic Co., Jamaica (E)
Extrusion machines: 8—1½" to 4½"
Pres.—A. D. Seidman
Vice Pres., Sales Mgr.—Sidney Seidman
Vice Pres.—George J. Seidman
Sales Mgr., Pur. Agt.—Irving Steinberg

***Ace Plastic Molding Corp.,** Long Island City (I)
Injection machines: 1—¼ oz.; 2—8 oz.
Pres.—Peter M. Miale

***American Plasticraft Co.,** New York (I)
Injection machines: 5—2 to 2½ oz.
Partners—Frank Yablon, Leo Cooper

***American Plastics Corp.,** New York (C, E, I)
Compression presses: 10
Extrusion machines: 3
Injection machines: 20

★*Anchor Plastics Co., Inc., Long Island City (E)
Extrusion machines: 1—1½"; 1—1¾"; 2—2¾"; 4—3½"; 10—2½"
Pres., Sls. Mgr.—Richard A. Fisch
Vice Pres.—Myron Rothman
Pur. Agt.—Leo Gans

Aries Laboratories, Inc., Long Island City (C)
Compression presses: 2 presses, 6 platen
Pres.—H. Isbenjian
Vice Pres.—E. A. Aries
Sls. Mgr.—W. Stern
Pur. Agt.—H. Grisar

Art Plastics Co., Woodside (I)
Injection machines: 2—4 to 6 oz.; 2—2½ oz.

★*Auburn Plastics, Inc., Auburn (C, E, I)
Compression presses: 10—automatic rotary; 3—15 ton automatic
Extrusion machines: 8—from 1½" to 4½"; 4—3½", 4½", 5"
Injection machines: 25—1 oz. to 40 oz.
Pres.—John H. Woodruff
Vice Pres.—E. M. Woodruff
Vice Pres.—Douglas Woodruff Jr., M. R. Turrell
Pur. Agt.—Geo. H. Johnson

***Augusta Plastics, Inc.,** Bronx (I)
Injection machines: 1—2 oz. to 3 oz.; 1—4 oz. to 6 oz.; 6—12 oz. to 16 oz.
Pres.—Stanley Sapery
Treas., Pur. Agt.—Murray Nader

***Axel Plastics Research Laboratories,** Brooklyn (CM)
Pres.—R. R. Axel
Sls. Agt.—J. D'Avanzo
Pur. Agt.—A. Axel

Beacon Plastic & Metal Products, Inc., New York (I)
Injection machines: 4—½ oz. to 16 oz.
Pres.—I. Martin Spier

***Bernard Plastics Molding Corp.,** Long Island City (I)
Injection machines: 1—2 oz.; 2—6 oz.; 1—8 oz.; 1—12 oz.; 2—16 oz.

Bo-Mer Mfg. Co., Inc., Auburn (C)
Compression presses: 3—30 ton; 1—50 ton; 1—150 ton
Pres.—K. H. Bowen
Vice Pres., Sales Mgr.—T. E. Dennett
Pur. Agt.—T. Bennett

***Bricmar Mfg. Corp.,** New York (E, I)
Extrusion machines: 1—⅛" 1—1⅛"; 2—2"; 2—3¼"
Injection machines: 1—1 oz.; 2—2 oz. to 3 oz.; 1—4 oz.; 1—6 oz.; 6—8 oz.; 4—12 oz.; 2—16 oz.
Pres., Sls. Mgr.—Herman J. Brickman
Vice Pres.—Bert B. Brickman
Pur. Agt.—Gene Siciak

***Brilhart Plastics Corp.,** Mineola (C, I, T, CM)
Compression Presses: 1—40 ton, 1—30 ton, 1—10 ton, 3—20 ton, 4—30 ton, 6—50 ton
Injection machines: 1—32 oz., 1—16 to 20 oz., 6—12 oz., 3—8 oz., 4-6 oz., 2-4 oz., 8-1 oz.
Transfer presses: 1—400 ton, 1—125 ton, 1—100 ton, 1—50 ton
Pres.—J. M. F. Conrad
Vice Pres.—A. W. Cummings
Sls. Mgr.—T. C. Ackerly
Pur. Agt.—W. Shea

***Chili Plastics, Inc.,** N. Chili (I)
Injection machines: 6—2 to 8 oz.; 2—4 to 6; 2-8 oz.; 1—6 oz.; 1—2 oz.

★*Contour Extrusion Co., Mamaroneck (E)
Extrusion machines: 6—1½" to 2½"
Co-owners—J. Dukess, H. Van Leeuwen

***Cotton & Co., C. B., Inc.,** Brooklyn (I)
Injection machines: 2—4 oz. to 6 oz.; 2—8 oz.; 1—12 oz.; 1—12 oz. to 16 oz.; 1—16 oz. to 20 oz.
Pres.—Chester B. Cotton
Vice Pres., Sls. Mgr.—Royden B. Edwards
Pur. Agt.—George M. Blumenthal

Cox Plastics Corp., Buffalo (C, T)
Compression presses: 6—up to 300 ton
Transfer presses: 3—up to 300 ton
Pres., Sls. Mgr.—James V. Cox
Vice Pres., Pur. Agt.—Eugene Hiller

Crellin Plastics Corp., Chatham (I)
Injection machines: 1—2 oz.; 4—8 oz.; 3—16 oz.; 1—20 oz.
Pres.—John R. Crellin, Sr.
Pur. Agt.—Arthur W. Brusie

Curtiss-Wright Corp., New York (I)
Injection machines: 4—up to 48 oz.
Gen. Mgr.—Dr. K. F. Hager
Dir. of Sls.—L. Wimmer
Pur. Agt.—Wm. Yanko

***Debo Mfg., Co., L. F.,** Depew, (I)
Injection machines: 1—2 oz.; 1—4 oz.
Pres.—Leroy Debo
Vice Pres.—Florence Debo

★DeWitt Plastics Div., Shoe Form Co., Inc., Auburn (E)
Extrusion machines: 1—3½"
Pres.—Frank P. DeWitt
Vice Pres.—Wm. J. DeWitt, Jr.
Sls. Mgr.—David E. Gregory
Pur. Agt.—Gordon N. Tutton

***Diemolding Corp.,** Canastota, (C, T)
Compression presses: 55—35 to 500 ton
Transfer presses: 15—25 to 500 ton
Pres.—Donald H. Dew
Vice Pres.—Donald Dew Jr.
Vice Pres. & Sls. Mgr.—B. Jarvis Dew
Pur. Agt.—L. Brooks

Eagle Molding Corp., Brooklyn (I)
Injection machines: 4—8 oz.

***Eagle Plastics Corp.,** Long Island City
Compression presses: 15 ton; 300 ton
Injection machines: 4 oz.
Transfer presses: 50 ton

***Emerson Plastics Corp.,** Bronx (C, E)
Compression presses: 3—up to 60 tons
Extrusion machines: 5—up to 1¼"
Pres.—W. Elsfelder
Vice Pres. & Sales Mgr.—A. Margosian
Pur. Agt.—Don Singer

Excel Plastic Mfg. Corp., New York (I)
Injection machines: 1—4 oz.; 4—8 oz.; 1—12 oz.; 1—20 oz.
Pres., Pur. Agt.—Adolph Dellheim
Vice Pres.—Ilse Dellheim

***Farragut Plastics Corp.,** Brooklyn (I)
Injection machines: 6—9 oz.; 12—16 oz.
Pres.—Howard W. Partridge
Vice Pres. & Sls. Mgr.—Milton S. Hoffman
Pur. Agt.—Moe Hoffman

Frisch Doll Supply Co., Inc., New York (I)
Injection machines: 2—16 oz.
Pres.—Anna F. Schwartz
Sls. Mgr. & Pur. Agt.—M. M. Schaffer
Vice Pres.—Ben Stern

***Gabriel Mfg. Co.,** Haverstraw (I)
Injection machines: 1—2 oz.; 2—4 oz.; 3—9 oz.; 1—12 oz.
Pres.—Ed Gabriel
Vice Pres. & Pur. Agt.—Robert Gabriel
Sales Mgr.—Mel Harris

***Gary Enterprises, Inc.,** Brooklyn (I)
Injection machines: 1—4/6 oz.; 4—12/16 oz.; 2—8 oz.; 1—10 oz.; 1—12 oz.; 2—16 oz.
Pres.—R. B. Fritzhand
Pur. Agt.—M. M. Printz

***Gemloid Corp.,** Long Island City (I)
Injection machine: 1—4 oz.; 2—8 oz.; 2—12 oz.; 2—16 oz.
Pres., Sls. Mgr.—Leonard E. Elterman
Vice Pres.—Carl Haller
Pur. Agt.—R. Johnstone

***Glass Laboratories, Inc.,** Brooklyn (E, I)
Pres.—A. Shanok
Vice Pres.—Jesse Shanok
Sales Mgr.—I. Jacobs
Pur. Agt.—Victor Shanok

***Gries Reproducer Corp,** New Rochelle (I)
Injection machines: 17—.03 oz.
Pres.—Otto Gries
Vice Pres.—A. Ehbrecht
Sales Mgr.—Carl Chase
Dir. of Sales—Joseph Saks
Pur. Agt.—Robert Barlow

***Guild Molders, Inc.,** Elmsford (I)
Injection machines: 2 oz.; 4 oz.
Pres.—Emil Davidson

***Haller Plastics Corp.,** Long Island City (I)
Injection machines: 2—4 to 6 oz.; 2—8 oz.; 1—12 oz.; 3—12 to 16 oz.
Pres.—Carl Haller
Vice Pres.—Joseph F. Slater
Sls. Mgr.—G. Landsberger
Pur. Agt.—J. Cruger

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* Operates own tool room
★ Indicates Advertiser

Holman Mfg. Co. Inc., Hoosick Falls (C, I)
Compression presses; 17—5 to 150 tons; 1—50 ton
Injection machines: 1—2 oz.; 1—12 oz.
Pres.—Arthur R. Tinnerholm
Vice Pres.—Blanche Tinnerholm
Sales Mgr.—Herbert H. Shepardson
Pur. Agt.—Sanford L. Cluett Jr.

★**Hopp Plastics, Div. of the Hopp Press Inc.,** New York (I)
Injection machines: 2—8 oz.
Pres.—Hermann Hopp
Vice Pres.—Philip Hopp
Vice Pres.—George Hopp
Sls. Mgr.—Ed. Autler

***Hydro Molding Co., Inc.,** Plattsburgh (C, I, T)
Compression presses: 12—16-175 ton
Injection machines: 16—1½-12 oz.
Transfer presses: 3—60-175 ton

★***Ideal Plastics, Div. of Ideal Toy Corp.,** Hollis (I)
Injection machines: 8—3 oz.; 10—4 oz.; 30—8 oz.; 2—9 oz.; 14—12 oz.; 2—16 oz.; 9—20 oz.; 4—32 oz.; 2—48 oz.; 2—60 oz.
Pres.—D. Rosenstein
Vice Pres.—Lionel Weintraub
Treas. & Prod. Mgr.—A. M. Katz
Vice Pres. Plastic Sales—A. C. Manovill
Pur. Agt.—L. Hansburg

***Industrial Sales Engineers,** N. Y. (E, I)
Extrusion machines: 8—1½ to 4½"
Injection machines: 10—2 oz. to 22 oz.
Pres. & Sls. Mgr.—L. H. Posner
Vice Pres.—S. Posner
Pur. Agt.—S. Logan

***Injection Molding Corp.,** New York (I)
Injection machines: 12—4 oz. to 32 oz.
Pres.—Daniel D. Whyte
Vice Pres.—Jay J. Whyte
Vice Pres. & Sls. Mgr.—Nicholas Klein
Treas.—Herman Whyte

★**Insulation Mfg. Co. Inc.,** Bklyn., (C, T)
Compression presses: 50—15-450 ton
Transfer presses: 8—22-450 ton
Pres.—Ethel L. Starke
Vice Pres. & Prod. Mgr.—G. W. Starke
Sales Mgr.—Robert W. Starke
Gen. Mgr. & Pur. Agt.—E. Steinberger
Plant Mgr.—C. N. Starke

International Plastic Co., N. Y. (C, E)
Compression presses: 1—2 oz.; 1—8 oz.; 1—12 oz.
Extrusion machines: 1—3"

***Jamison Plastic Corp.,** North Bellmore (I)
Injection machines: 13—2 to 32 oz.
Pres.—Harry Jamison
Vice Pres.—Stanley Bindman
Sls. Mgr.—Howard Farber
Treas.—Jack Jamison
Pur. Agt.—Joseph Bonifazio

***Jay Moulding Corp.,** Cohoes (E, I)
Compression presses: 1—50 ton; 1—100 ton; 1—250 ton
Transfer presses: 1—50 ton; 1—250 ton
Pres. & Sls. Mgr.—Jacob M. Weinberg
Vice Pres.—Dudley R. Myer
Pur. Agt.—S. Weinberg

***Jodee Plastics, Inc.,** Brooklyn (E, I)
Extrusion machines: 1—2⅜", 1—3¼"
Injection machines: 1—2 oz., 1—8 oz.
Pres. & Sls. Mgr.—Nicholas Meglino
Vice Pres. & Pur. Agt.—Josephine Meglino

Kwik-Mold Plastic Corp., N. Y. (I)
Injection machines: 2—16 oz.; 4-8 oz.; 2—4 oz.
Pres., Sls. Mgr. & Pur. Agt.—Joseph Pearlman
Vice Pres.—Sidney Salwen

***Leaf Plastics, Inc.,** Yonkers (I)
Injection machines: 10—up to 24 oz.
Pres. & Pur. Agt.—George W. Leaf
Vice Pres. & Gen. Mgr.—Ludwig Leaf
Plant Mgr.—Lester Gabriel
Sec.-Treas.—Dr. Wm. R. Leaf

Lumelite Corp., Pawling (I)
Injection machines: up to 4 oz.
Pres.—H. W. Williams
Sls. Mgr.—F. E. Weddell

***Mastro Plastics Corp.,** New York (E, I)
Extrusion machines: 1—2½"; 1—4½"
Injection machines: 2—4 oz.; 1—6 oz.; 11—8 oz.; 6—12 oz.; 3—16 oz.; 1—24 oz.
Pres., Sls. Mgr.—Marie Maccaferri
Vice Pres.—C. A. Sherman
Pur. Agt.—H. K. Chadakoff

***Molded Industrial Plastics, Inc.,** Flushing (I)
Injection machines: 1—2 oz.; 1—4 oz.; 1—9 oz.; 1—16 oz.
Pres., Sls. Mgr., Pur. Agt.—I. Allen

The Nalge Co. Inc., Rochester (I)
Injection machines: 1—1 oz.; 2—special 40 oz.
Pres.—Emanuel Goldberg
Pur. Agt.—Richard T. Cleaver

***National Plastic Corp.,** Bklyn., (I)
Injection machines: 8—2 to 16"
Pres.—Noah Rubin
Vice Pres.—Jack Rubin

Norton Laboratories, Inc., Subsidiary of Auburn Plastics, Inc., Lockport, (C, I, T)
Compression presses: 32—from 50 ton to 450 ton
Injection machines: 13—from 1 oz. to 16 oz.
Transfer presses: 29—from 75 ton to 500 ton
Pres.—John H. Woodruff
Exec. Vice Pres.—K. O. William Sandberg
Vice Pres.—James B. Neal
Sls. Mgr.—Howard O. Painter

Plasticite Corp., New York (I)
Injection machines: 4 to 16 oz.
Pres.—Effram Arenstein
Vice Pres.—Seymour Arenstein

***Plastiline, Inc.,** White Plains (I)
Injection machines: 3—8 oz.; 2—16 oz.; 2—12 oz.
Pres.—B. N. Batzer
Sales Mgr.—G. R. Quinn
Treas.—M. A. Batzer
Pur. Agt.—T. Fletcher

Plasti-Skill Co., Corona (CM)
Personnel: see p. 1187

***Poly-Cell Plastics Co.,** Smithtown (E)
Extrusion machines: 7—up to 4½"
Pres., Pur. Agt.—J. Rosenberg
Vice Pres., Sls. Mgr.—R. Rosenberg

***Progressive Plastics Manufacturing Co.,** Bronx (I)
Injection machines: 13—from 4 oz. to 20 oz.

***R. C. Molding, Inc.,** New Hyde Park (I)
Injection machines: 5—4/6 oz.; 2—12 oz.; 4—12/16 oz.
Pres.—B. E. Wessinger
Vice Pres., Sls. Mgr.—G. P. Humphrey

***Robinson Plastics Corp.,** New York (I)
Injection machines: 1—2 oz.; 3—12 oz.; 2—16 oz.

★**Rotuba Extruders, Inc.,** Brooklyn (E, I)
Extrusion machines: 18
Injection machines: 4
Pres.—Walter Bell
Vice Pres.—John Novelo
Sls. Mgr.—Herbert Weber
Pur. Agt.—Martin Muckler

***Silicone Insulation, Inc.,** Bronx (C)
Compression presses: 12—to 75 ton
Pres.—W. Elsfelder
Vice Pres., Sls. Mgr.—A. Margosian
Pur. Agt.—Don Singer

Specialty Insulation Mfg. Co., Inc., Hoosick Falls (C, T)
Compression presses: 2—12 ton; 22—25 ton; 12—50 ton; 10—75 ton; 6—100 ton; 2—175 ton; 2—400 ton
Transfer presses: 2—12 ton; 4—25 ton; 6—50 ton; 8—75 ton; 8—100 ton; 1—175 ton
Pres., Sls. Treas.—Edmund J. Skorupski
Vice Pres.—Harold H. Rice
Pur. Agt., Sec.—Carl J. Kempf

Sterling Molders, Inc., Buffalo (I)
Injection machines: 3—12 oz., 1—10 oz., 3—8 oz., 9—6 oz., 1—4 oz., 1—3 oz., 2—2 oz.
Pres.—John Hammond Kirk
Vice Pres.—Paul H. Bronnenkant

***Streamline Plastics Co.,** New York (E, I)
Extrusion machines: 6
Injection machines: 11
Partners—Sol Bartner, M. J. Schlussel, Morton Schlussel, Ed Schlussel

***Syracuse Plastic Molders,** Syracuse (I)
Injection machines: 2
Partners—J. R. Falcone, Anthony Falcone, Jr.

★**Thermold Corp.,** Manlius (I)
Injection machines: 1—16 oz., 1—2 oz., 3—8 oz., 1—12 oz.
Pres., Sls. Mgr.—Wallace B. Ross
Vice Pres.—Charles M. Farley
Pur. Agt.—E. H. Ethridge, Jr.

Tico Plastics, Inc., N. Y. (E,I)
Extrusion machines: 4—1¼ to 3½"
Injection machines: 11—8-22 oz.
Pres. & Sls. Mgr.—Saul Blitz
Vice Pres.—J. S. Kirstein
Pur. Agt.—Charles E. Cohen

***Tri-Point Plastics, Inc.,** Albertson (E)
Extrusion machines: 8—⅛" to 2"
Pres.—Sal Mulay
Vice Pres.—Jack Kipnes
Sls. Mgr.—Pat Ruggieri
Pur. Agt.—Sid Kipnes

Trimold, Inc., Kenmore (I)
Injection machines: 2—4 oz. to 6 oz.; 3—8 oz.; 1—9 oz.
Pres., Pur. Agt.—C. R. Witt
Vice Pres., Sls. Mgr.—S. M. Knapp, Jr.

United Mask & Novelty Co., Inc., Glendale (C)
Compression presses: 1—75 ton
Pres.—Elwood G. Pamatat
Vice Pres., Pur. Agt.—Clinton Pamatat
Sls. Mgr.—Hilda Pamatat

***Voges Mfg. Co., Inc.,** Ozone Park (I)
Injection machines: 10—2 oz. to 28 oz.

★***Vogt Mfg. Corp.,** Rochester (E, I)
Extrusion machines: 16—up to 4½"
Injection machines: 2—up to 2 oz.
Pres.—L. S. Foulkes, Jr.
Vice Pres., Sls. Mgr.—R. A. Lander, Jr.
Pur. Agt.—A. Odell

★***Waljohn Plastics, Inc.,** Brooklyn (E, I)
Extrusion machines: 16
Injection machines: 4
Pres.—Walter Bell
Sls. Mgr.—Herb Weber
Pur. Agt.—Martin Muckler

Westplex Corp., Rochester (I)
Injection machines: 1—2 oz.; 1—3½ oz.; 3—6 oz.; 2-10 oz.; 1—12 oz.
Pres.—J. A. West, Jr.
Vice Pres.—E. G. Ritter
Sls. Mgr.—R. E. Lee

***White Dental Mfg. Co., S. S., Industrial Div.** New York (C, E, I, T)
Compression Presses: 2—25 ton; 4—175 ton
Extrusion machines: 1—4"
Injection machines: 12—2½ oz. to 12 oz.
Transfer presses: 1—200 ton
Pres.—F. E. Steen
Vice Pres., Plant Mgr.—W. P. Uhler
Sls. Mgr.—G. T. Latimer

***Whyte Mfg. Co., Inc.,** New York (I)
Injection machines: 12—4 oz. to 32 oz.
Pres.—Daniel D. Whyte
Vice Pres., Sls. Mgr.—Nicholas Klein
Vice Pres.—Jay J. Whyte
Pur. Agt.—Herman Whyte

★**Woloch, George, Co., Inc.,** New York (E)
Extrusion machines: 8
Pres.—George Woloch
Vice Pres.—Harding Miller
Sls. Mgr.—Wm. Silberstien
Pur. Agt.—Edgar L. Baker

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* Operates own tool room
★ Indicates Advertiser

***World Plastics**, New York (E, I)
Extrusion machines: 1–1½"; 2–2"; 1–2⅛"; 3–3¼"
Injection machines: 1–16 oz.
Partners—Milton Book, George Strisguth, Leon A. Cook
Sls. Mgr.—E. B. Leimseider

NORTH CAROLINA

***Carolina Industrial Plastics Div., Essex Wire Corp.**, Mt. Airy (E)
Extrusion machines: 15
Pres.—D. L. Webb
Sales Mgr.—William W. Chapman
Pur. Agt.—L. B. Webb

***Southern Plastics Engineering Corp.**, Greensboro (C, I, T)
Compression presses: 5–from 15 ton to 350 ton
Injection machines: 5–from 1/3 oz. to 22 oz.
Transfer presses: 3–from 30 ton to 90 ton
Pres., Pur. Agt.—J. W. Worsham
Vice Pres., Sls. Mgr.—Andrew Westhead

OHIO

***Ackerman Plastic Molding Div., Consolidated Iron-Steel Mfg. Co.**, Cleveland (T)
Transfer presses: 11–100 ton to 385 ton
Pres.—L. S. Cawrse
Vice Pres.—J. F. Maine, J. Hanks
Gen. Mgr.—A. F. Kuthe

***Adams Plastic Products**, Cincinnati (I)
Injection machines: 1–3 oz.; 1–8 oz.; 1–10 oz.
Pres.—Raymond N. Adams
Gen. Mgr.—Wesley A. Weaver
Treas.—Mary D. Adams

Allied Resins, Inc., Conneaut (C, E)
Compression presses: 1–500 ton
Extrusion machines: 3–8½"; 4–6"; 6–4½"; 1–2½"; 1–1"
Pres.—E. J. Malek
Vice Pres.—N. K. Anderson
Sales Mgr.—S. W. Hubbard
Pur. Agt.—J. Moneypenny

***American Agile Corp.**, Bedford (E, I)
Extrusion machines: 3–2½"
Injection machines: 1–22 oz., 1–160 oz.
Pres.—J. A. Neumann
Vice Pres., Sls. Mgr.—C. F. Freedman
Pur. Agt.—V. S. Balogh

Argo Plastic Products Co., Cleveland (E, I)
Extrusion machines: 1–1½"
Injection machines: 1–16 oz.
Pres.—H. L. Dlott
Vice Pres., Sls. Mgr.—D. E. Grant

★**Barron Plastics, J. E., The**, Cincinnati (I)
Injection machines: 1–2½ oz.
Pres., Pur. Agt.—S. J. Johnson
Vice Pres., Sls. Mgr.—Arthur Cole

Bluebird Plastics, Inc., Coshocton (I)
Injection machines: 1–8 oz.; 1–16 oz.; 2–28 oz.
Pres.—W. D. Timmons, Sr.
Vice Pres.—R. K. Fox
Gen. Mgr., Sales Mgr. & Pur. Agt.—Edward B. Dennison

***Buckeye Molding Co.**, Miamisburg
Injection machines: 14–4 to 16 oz.
Pres.—W. H. Robinson
Vice Pres.—E. W. Robinson
Sales Mgr.—C. R. Scheuring
Pur. Agt.—W. E. Koons

C.T.L., Inc., Cincinnati (C)
Compression presses: 4–75 ton; 3 toggle; 1–100 ton; 1–1000 ton
Pres.—E. P. Warnken
Vice Pres.—M. N. Korelitz
Sls. Mgr.—J. D. Flynt
Pur. Agt.—C. A. Morrow

***Campro, The, Co.**, Canton (I)
Injection machines: 16–6 oz. to 32 oz.
Pres.—Albert Harris
Vice Pres.—Charles Wolk
Sales Mgr.—Robert Sweaney
Pur. Agt.—Robert Arner

***Canton Containers, Inc.**, Canton (E)
Extrusion machines: 2
Pres.—Paul Heller
Vice Pres.—Ralph Heller
Gen. Mgr.—Robert Fulmer

***Carlon Products Corp.**, Aurora (E, I, T)
Extrusion machines: 47
Injection machines: 3
Transfer presses: 7
Pres.—W. L. Abramowitz
Vice Pres.—Irving Abramowitz, Philip Britton
Sales Mgr.—Thomas Dunn
Gen. Mgr.—James D. Cleminshaw
Pur. Agt.—Rudolph Kustra

***Champion Molded Plastics, Inc.**, Bryan (I)
Injection machines: 18–4 oz. to 48 oz.
Pres., Sales Mgr.—L. L. Phillips
Vice Pres.—G. H. Hester
Pur. Agt.—J. C. Sloan

***Cincinnati Molding Co.**, Cincinnati (C)
Compression presses: 6–50 ton

***Columbus Plastic Products, Inc.**, Columbus (I)
Injection machines: 58–1 oz. to 200 oz.
Pres.—G. W. Keny
Vice Pres.—W. J. Braley
Sls. Mgr.—D. S. Poulton
Pur. Agt.—H. L. Schafer

***Conneaut Rubber & Plastics Co.**, Conneaut (E)
Extrusion machines: 8
Pres.—J. M. W. Chamberlain
Vice Pres.—Robert C. Hunter
Sls. Mgr.—J. H. Davison
Pur. Agt.—J. B. Phipps

***Cosmo Plastics Co.**, Cleveland (I)
Injection machines: 1–6 oz.; 3–8 oz.; 5–12 oz.
Pres.—I. Gordon
Vice Pres.—A. Gordon
Sls. Mgr.—B. Gordon

***Crane Associates, Robert S.**, Columbus (E)
Extrusion machines: 7–up to 4½"
Pres., Pur. Agt.—R. S. Crane
Vice Pres., Sls. Mgr.—R. S. Crane, Jr.

D & G Plastics Company, Kent
Injection machines: 1–8 oz.; 1–10 oz.; 1–20 oz.
Partners—D. L. Davenport & Victor Gontero
Sls. Mgr.—Luke Sewell
Pur. Agt.—Charles Marshall

***Dimco-Gray Co.**, Dayton (C, T)
Compression presses: 16–5 to 400 ton
Transfer presses: 4–60 to 140 ton
Man. Partner—F. E. Gray
Partner & Ch. Eng.—R. K. Gray
Sales Mgr.—C. F. Dearth
Partner & Pur. Agt.—J. D. Gray
Ass't Gen. Mgr.—R. A. Wright

***Electric Auto-Lite Co., The**, Toledo (C, I, T)
Compression presses: 40–from 15 ton to 423 ton
Injection machines: 26–from 6 oz. to 28 oz.
Transfer presses: 21–from 50 ton to 350 ton
Pres.—J. P. Falvey
Vice Pres.—R. E. Valk
Sls. Mgr.—S. T. Rose
Pur. Agt.—H. Ricker

Elyria Molding & Engineering Co., Elyria (C, I, T)
Compression presses: 3–50 ton
Injection machines: 3–8 oz. to 20 oz.
Transfer presses: 10–75 ton to 350 ton

***F & F Mold & Die Works, Inc.**, Dayton (I)
Injection machines: 11–4 oz. to 22 oz.
Pres.—John G. Fiedler
Vice Pres.—Otto E. Fiedler
Sls. Mgr.—John G. Braden

Fenco Mfg. Co., Akron (I)
Injection machines: 3–8 oz.; 4–12 oz.; 2–16 oz.; 2–20 oz.
Pres.—J. V. Ferriot
Vice Pres., Prod.—G. F. Keeler
Vice Pres.—G. H. Ferriot
Comptroller—Wm. B. Poe
Treas.—E. F. Ferriot

Francis Industries, Pataskala (E, T)
Extrusion machines: 3
Transfer presses: 1
Pres. & Sls. Mgr.—Richard J. Francis
Vice Pres. & Pur. Agt.—C. A. Francis

***Geauga Industries Co.**, Middlefield
Extrusion machines: 2–2½"; 2–3½" 1–4⅛"
Pres.—Ellis H. Clark
Vice Pres.—Adrian Welch
Vice Pres.—Hugh M. Johnson
Sales Mgr.—Paul W. Boorn
Pur. Agt.—John F. Lockhart

★***General Industries Co., The**, Elyria (C, I, T)
Compression presses: 112–30 to 1800 ton.
Injection machines: 18–8 oz. to 200 oz.
Transfer presses: 30–100 to 425 ton
Pres.—Wm. E. Foster
Vice Pres. and Mgr., Plastics Div.-Morris Barchard
Chairman of the Board—A. W. Fritzche
Dir. of Engr.—R. L. Smith
Ch. Eng.—D. F. Bubb
Sales Mgr.—J. M. Callihan
Pur. Agt.—C. W. Heidrich

Globe Molded Plastics, Inc., Byesville (I)
Injection machines: 1–4 oz.; 2–16 oz.
Pres.—Verland E. Frederick
Vice Pres.—Lewis H. Matheny
Sales Mgr. & Pur. Agt.—A. T. Gander

***Greene & Co., Ray**, Toledo (C)
Compression presses: 3–50 ton; 1–150 ton
Pres.—Ray Greene
Vice Pres.—Jan Greene
Sales Mgr.—Robert Crist
Pur. Agt.—Ken Greene

Harcort Mfg Co., The, Ravenna (C, I)
Compression presses: 17
Injection machines: 7

Industrial Plastics, Inc., Cleveland (I)
Injection machines: 2–12 oz.; 1–3 oz.
Pres.—Robert H. Rodgers
Sls. Mgr.—F. Scott Rodgers
Pur. Agt. & Plant Mgr.—Heinz Kroeger

Ingwersen Manufacturing Co. Inc., Denver (I)
Injection machines: 1–4 oz.; 1–12 oz.; 2–6 oz.
Pres. & Sls. Mgr.—T. E. Taplin
Vice Pres. & Pur. Agt.—J. E. Dilatush

★**Kurz-Kasch, Inc.**, Dayton (C)
Compression presses: 94–6 to 500 ton
Pres. & Treas.—W. G. Davidson
Vice Pres. & Sls. Mgr.—R. L. Davidson
Vice Pres.—F. R. Kiernan
Pur. Agt.—I. H. Naas

L & P Tool Co., Cincinnati (C, E)
Compression presses: 1–50 ton
Injection machines: 1–1½"

Lake Erie Plastic Co., Elyria (I)
Injection machines: 6–4 to 16 oz.
Pres.—O. F. Everitt

★***Lester Engineering Co.**, Cleveland (I)
Injection machines: 4 to 60 oz.
Pres.—David White

★***Lincoln Molded Plastics, Inc.**, Circleville (I)
Injection machines: 17: 1–6 oz.; 1–12 oz.; 9–16 oz.; 2–32 oz.; 2–48 oz.; 1–64 oz.; 1–200 oz.
Pres.—Harry Jenkins
Vice Pres.—M. W. Burkhart
Asst. Sls. Mgr.—D. E. Meyers

Majestic Molding Co., Elyria (I)
Injection machines: 1–4 oz.; 4–8 oz.; 2–16 oz.; 1–32 oz.

Mold-Rite Plastics, Inc., Cambridge (C, T)
Compression presses: 30–300 ton
Transfer presses: 50–300 ton
Pres.—L. F. James
Sec.-Treas.—R. L. James

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* Operates own tool room
★ Indicates Advertiser

*Munray Products Div., The Fanner Mfg. Co., Cleveland (C, E, I, T)
Compression presses: 1–15 ton; 1–20 ton; 1–40 ton
Extrusion machines: 5–2½"; 2–3½"; 1–4½"
Injection machines: 1–1½ oz.; 1–2 oz.; 1–4 oz.
Transfer presses: 1–20 ton; 1–40 ton; 1–100 ton
Pres.—T. Butz
Gen. Mgr.—S. M. Schlein
Sls. Mgr.—Vernon K. Jack
Pur. Agt.—L. Fallon

Napco Plastics, Inc., Napoleon (I)
Injection machines: 6—from 8 oz. to 32 oz.
Pres., Pur. Agt.—Paul W. Young
Vice Pres.—Richard W. Seislove

*Ohio Plastic Co., The, Frazeysburg (I)
Injection machines: 3–6 oz.; 2–9 oz.; 1–12 oz.; 2–16 oz.
Pres. & Gen. Mgr.—George N. Edwards
Pur. Agt.—Mary E. Moss

*Owens-Illinois Glass Co., Toledo (C, I)
Compression presses: 1–60 ton
Injection machines: ½ oz. to 12 oz.
Pres.—C. R. Megowen
Vice Pres.—G. S. Babcock
Gen. Mgr., Closure & Plastics Div., G. S. Babcock
Sls. Mgr., Closure & Plastics Div., J. S. Rudy
Pur. Agt.—M. S. Carr

*Payne Tool & Engineering Co., The Springfield (C, I)
Compression presses: 1–2080 ton
Injection machines: 2–4 oz.
Pres., Sls. Mgr., Pur. Agt.—Albert Ed. Payne

*Peerless Molded Plastics, Inc., Toledo (C, I, T)
Compression presses: 6–50 tons; 2–150 tons; 9–75 tons; 1–200 tons; 1–300 tons
Injection machines: 3–2½ oz.; 1–4 oz.; 6–4-6 oz.; 2–6 oz.; 1–8 oz 1–9 oz.; 1–12 oz.
Transfer presses: 6–75 ton; 1–150 ton; 1–200 ton
Pres., Treas. & Sls. Mgr.—W. C. Skutch, Jr.
Vice Pres. & Sec'y.—R. E. Wagner
Pur. Agt.—J. Tochtermann

*Plaskolite, Inc., Columbus (E)
Extrusion machines: 1–4½, 1–3½, 2–2½, 2–2", 1–1½"
Pres.—Donald G. Dunn
Vice Pres.—Norris H. Olson

*Plastex Co., The, Columbus (E)
Extrusion machines: 1–2½"; 6–3½"; 3–4½"
Pres.—Richard S. Zimmerman
Vice Pres.—Robert O. Zimmerman
Pur. Agt.—Mack Rhulman

*Plastic Moldings Corp., Cincinnati (C, I)
Compression presses: 65–40 to 400 ton
Injection machines: 2–4 oz.; 1–2 oz.
Pres.—Edwin H. Gerdes
Vice Pres.—John E. Bast
Sls. Mgr.—Robert W. Gerdes
Pur. Agt.—Edwin J. Gerdes

*Plastic Research Products, Div. of Grimes Mfg. Co., Urbana (C, T)
Compression presses: 33–15 to 350 ton
Transfer presses: 16–50 to 350 ton
Pres.—Warren G. Grimes
Vice Pres.—Donald O. Printz
Sls. Mgr. & Pur. Agt.—R. E. Stockton

Plastic Toys Corp., Byesville (I)
Injection machines: 2–4 oz.
Pres. & Sls. Mgr.—O. J. Sharpe
Pur. Agt.—D. Gregory

*Plastico, Dayton (I)
Injection machines: 1–3 oz.; 3–9 oz.
Partners—Clifford E. Heggs, Beverly P. Heggs
Sls. Mgr.—Clifford E. Heggs

Precision Molded Plastics, Inc., Cleveland (I)
Injection machines: 4—capacity 4 oz. to 24 oz.

★*Recto Molded Products Co., Cincinnati (C, I, T)
Compression presses: 58–10 ton to 200 ton
Injection machines: 10–2 oz. to 8 oz.
Transfer presses: 1–80 ton; 1–200 ton
Pres.—N. A. Backscheider
Vice Pres.—Irvin Klein
Sls. Mgr.—R. N. Backscheider
Pur. Agt.—Lloyd S. Larrick

*St. Regis Paper Co., Panelyte Div., Cambridge (I)
Injection machines: 10—from 4 oz. to 120 oz.

Sajar Plastics, Inc., Middlefield (I)
Injection machines: 4–8 oz.; 1–24 oz.
Pres.—Arthur H. Radde
Sls. Mgr.—Hugh M. Johnson
Pur. Agt.—Robert N. Hills

★Schulman, A., Inc., Akron (E)
Extrusion machines: 3–6"; 1–8"; 2–8½"

★Seiberling Rubber Co., Plasics Div., Newcomerstown (C, E)
Compression presses: 2–5 deck; 1–6 deck; 1–8 deck
Extrusion machines: 2–3½"
Pres.—J. P. Seiberling
Vice Pres.—H. P. Schrank
Sls. Mgr., Plastics Div., C. J. Figenscher
Gen. Mgr., Plastics Div.—Harry M. Zimmerman

Shepherd Son & Co., J. H., Elyria (I)
Injection machines: 2–8 oz.

Standard Molding Corp., Dayton
Injection machines: 1–4 oz., 3–8 oz., 1–12 oz., 1–16 oz., 1–28 oz., 2–48 oz.
Pres.—W. F. Oelman
Vice Pres.—M. E. Koch
Sls. Mgr.—Richard Myers
Pur. Agt.—N. F. Patterson

★*Structurlite Plastics Corp., Hebron (C)
Compression presses: 16–25 to 500 ton with platen areas from 2′ to 6′ x 6′ daylight 24" to 94"
Pres.—Charles D. Jones
Sls. Mgr., Treas.—Robert E. Griffith
Pur. Agt.—L. R. Rose

Sun Plastic, Inc., Cuyahoga Falls (I)

Toledo Plastics Co., Toledo (C, I)
Compression presses: 1–50 ton
Injection machines: 1–2 oz.; 2–4 oz.; 2–8 oz.

Vacuum Plastics Corp., Columbus (E)
Extrusion machines: 1–2½"
Pres.—Herbert S. Cook
Pur. Agt.—M. L. Grosh

*Vlchek Tool Co., The, Cleveland (E, I)
Extrusion machines: 1–3½"
Injection machines: 2–2 oz.; 1–3 oz.; 1–4 oz.; 1–5 oz.; 1–6 oz.; 1–9 oz.; 2–12 oz.; 1–16 oz.; 2–24 oz.; 1–48 oz.
Pres.—E. C. Koster
Sls. Mgr.—D. T. Wynne
Pur. Agt.—. J. Tkach

Vulcan Corp., Cincinnati (I)
Injection machines: 3–12 oz.
Pres.—Joseph B. Reynolds
Vice Pres., Sls. Mgr.—E. V. Nelson
Pur. Agt.—Frank Edmisten

*Welch Plastics & Mfg. Co., Inc., Columbus (I)
Injection machines: 1–6 oz.; 3–8 oz.; 1–12 oz.; 2–16 oz.; 1–20 oz.
Pres.—Arthur R. Welch
Vice Pres., Sls. Mgr.—Ralph A. Welch
Pur. Agt.—John T. McManus

Wilson Plastics Inc., Sandusky (I)
Injection machines: 20
Pres.—O. C. Wilson
Sls. Mgr.—R. L. Motter
Pur. Agt.—W. A. Arnold

★*Yardley Plastics Co., Columbus (E, I)
Extrusion machines: 16–2½" to 6"
Injection machines: 20–20 to 64 oz.
Pres.—F. B. Hill, Jr.
Vice Pres.—W. E. Jacobson
Vice Pres., Sls. Mgr.—R. W. Rosel
Pur. Agt.—E. A. Jacobson
Sls. Mgr.-Custom Extr.—G. C. Fulmer

OKLAHOMA

Continental Plastics of Oklahoma, Oklahoma City (I)
Injection machines: 7–2 oz. to 48 oz.
Pres., Vice Pres., Sls. Mgr.—Ray Stroud
Pur. Agt.—Norma Treadway

OREGON

*Anderson Die & Mfg. Co., Portland (I)
Injection machines: 2–4 to 6 oz.
Pres.—George C. Anderson
Pur. Agt., Treas.—K. M. Evans

Beaman Plastics, Portland (C, I)
Compression presses: 1–90 ton; 1–300 ton
Injection machines: 1–16 oz.
Pres.—Thelma E. Beaman
Sales Mgr.—R. O. Morrison
Pur. Agt.—R. Goebel

*Columbia Basin Plastics Co., Portland (C, I)
Compression presses: 300 ton
Injection machines: 1–10 oz., 2–12 oz.
Pres.—James C. DeShazor, Jr.
Pur. Agt.—Kathleen M. Evans

Grant & Roth Plastics, Inc., Portland (C, I)
Compression presses: 1–300 ton
Injection machines: 3–4 oz.; 1–8 oz.
Pres. & Pur. Agt.—Merrill R. Roth
Sales Mgr.—Phil Fennelly

PENNSYLVANIA

*A. S. K. Plastic Mfg. Co., Philadelphia (I)
Injection machines: 6–1½ oz.; 2 oz.; 2 to 4 oz.; 4 oz.; 2½ oz.; 6 oz.

*Acme Plastic Products Co., Inc., Doylestown (C, T)
Compression presses: 15—up to 75 ton
Transfer presses: 2—up to 75 ton
Pres., Sales Mgr.—B. Emmett House
Pur. Agt.—M. S. Walther

*Allegheny Plastics, Inc., Coraopolis (C, E)
Compression presses: 2 automatic; 4–15 ton; 6 manual; 4–300 ton
Extrusion machines: 2 ram type presses for TFE resins
Pres.—James M. Yost
Vice Pres.—George P. O'Neil
Sls. Mgr.—William E. Moritz
Gen. Mgr., Pur. Agt.—Nate B. Maruca

★*American Insulator Corp., New Freedom (C, I, T)
Compression presses: 85–10 to 2000 ton
Injection machines: 14–4 to 48 oz.
Transfer presses: 16–40 to 650 ton
Pres.—E. J. Caughlin
Vice Pres.—B. F. Hantz
Sls. Mgr.—B. L. Attig
Pur. Agt.—A. L. Bortner

Applied Plastics Div., Keystone Brass Works, Inc., Erie (C, I, T)
Compression presses: 2–75 ton; 1–150 ton; 2–200 ton; 1–250 ton; 6–300 ton; 2–400 ton; 1–500 ton
Injection machines: 1–12 oz.
Transfer presses: 1–150 ton; 1–250 ton; 2–200 ton; 3–300 ton; 2–400 ton
Pres.—M. H. Rowley
Vice Pres., Gen. Mgr.—Lloyd T. Moore

*Byrd Plastics, Inc., Erie (I)
Injection machines: 1–4 oz., 2–8 oz. to 1–12 oz.

*Calcon Mfg. Co., Inc., Washington (E)
Extrusion machines: 2–3¼ in.; 1–4½ in.; 1–6 in.
Pres. & Sls. Mgr.—James C. Morosco

★*Consolidated Molded Products Corp., Scranton (C, I, T)
Compression presses: 50–25 ton to 500 ton
Injection machines: 30–2 oz. to 200 oz.
Transfer presses: 40–70 ton to 350 ton
Pres.—John O'Connell
Vice Pres., Supt.—E. W. Birney
Vice Pres., Sls. Mgr.—J. W. Pillinger
Pur. Agt.—Walter Golden
Secy.—J. E. McMahon

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* Operates own tool room
★ Indicates Advertiser

Curry Arts, Scranton (C)
Compression presses: 1–36" x 38", 4 openings
Pres., Sls. Mgr.–Harry H. Rosenthal
Vice Pres., Pur. Agt.–Kurt Adler

Erie Plastics Co., Erie (E)
Extrusion machines: 1–3½", 1–6"
Pres., Sls. Mgr., Pur. Agt.–Edward A. Zacks
Vice Pres.–Jeffrey A. Gage

★***Erie Resistor Co., Erie** (I)
Injection machines: 27–from 6 oz. to 120 oz.
Pres.–G. R. Fryling
Vice Pres., Mfg.–G. P. Fryling
Eng. Sls. Mgr.–J. B. Loefflen
Pur. Agt.–G. T. Griswold

Franklin Plastics, Inc., Franklin (E, I)
Extrusion machines: 2–2½; 3–3½; 2–4½
Injection machines: 1–6 oz.; 1–8 oz.; 1–12 oz.; 1–16 oz.
Pres.–Dixon P. Downey
Vice Pres.–R. J. Litzinger
Sls. Mgr.–B. E. Tate

Gessner Mfg. Co., Ambler (C, I)
Compression presses: 6–15 to 50 ton
Injection machines: 2–2 oz.
Pres. and Sales Mgr.–Edward H. Gessner

H & R Industries, Nazareth (E, I)
Extrusion machines: 11–2 to 3½"
Injection machines: 6–2 oz. to 16 oz.
Pres.–J. John Hauck
Vice Pres. & Pur. Agt.–Elton M. Roeder
Sls. Mgr.–C. Forrest Bowers

Halsey, Inc., Scranton (C)
Compression presses: 2–25 tons; 1–50 tons; 2–200 tons; 2–300 tons
Pres., Sls. Mgr. & Pur. Agt.–Halsey J. Sorrell
Vice Pres.–C. W. Hupfer

Insulation Products Co., Pittsburgh (C)
Compression presses: 2 automatic (Stokes); 4–30 to 100 tons
Pres.–M. G. Rensland
Sls. Mgr., Pur. Agt.–H. A. Rensland

Keystone Packaging Service, Easton
Extrusion machines: 1–2½"; 2–1½"
Pres., Pur. Agt.–John Schoeneck

***Loranger Mfg. Corp., Warren** (C, I, T)
Compression presses: 12–15 to 700 ton
Injection machines: 1–4 oz.
Transfer presses: 6–200 to 300 ton
Pres.–J. Albert Loranger
Sls. Mgr., Pur. Agt.–Howard N. Boyd

Ludascher, William C., Eddington (I)
Injection machines: 1–4 oz.
Owner–William C. Ludascher

***Mannesmann-Easton Plastic Products Co., Inc., Easton** (E)
Extrusion machines: 7
Pres.–Dr. G. Wagner
Vice Pres., Gen. Mgr.–Harvey G. Wismer

***Molded Insulation Co., Philadelphia** (C, I, T)
Compression presses: 40–5 ton to 300 ton
Injection machines: 22–1 oz. to 120 oz.
Transfer presses: 10–1 ton to 150 ton
Pres.–Wm. T. Bradbury
Vice Pres.–R. F. Hurst
Sls. Mgr.–Wm. Berger
Pur. Agt.–M. Halamar

Niagara Plastics Co., Erie (I)
Injection machines: 2–4 oz.; 1–6 oz.; 1–12 oz.; 1–3 oz.; 1–32 oz.
Pres. & Sls. Mgr.–James L. Rooney
Secy.–Robert Brown
Pur. Agt.–Robert P. Rooney

Nosco Plastics, Inc., Erie (I)
Injection machines: 23–2 oz.-200 oz. automatic
Pres.–R. C. Houser
Vice Pres. & Sls. Mgr.–P. C. Roche
Pur. Agt.–C. G. Wingerter

Optics Manufacturing Corp., Philadelphia (C)
Compression presses: 1–120 ton; 1–125 ton
Pres.–C. B. Mitchell
Exec. Vice Pres.–H. R. Leopold
Sls. Mgr. (Ind. Div.)–W. S. Victor
Pur. Agt.–M. F. Kaufman

Parker Plastics Corp., Pittsburgh (I)
Injection machines: 1–12 oz.; 1–10 oz.; 1–2½ oz; 1–2 oz.
Pres.–Mitchell Parker
Vice Pres.–Mitchell T. Parker
Sls. Mgr. & Pur. Agt.–Chester F. Stuver

Pelmor Laboratories, Inc., Newton (C)
Compression presses: 1–50 ton, 2–70 ton
Pres.–Coleman P. Morgan
Vice Pres.–Emelie A. Pelham
Pur. Agt.–Ronald B. Morgan

***Penn-Plastics Corp., Glenside** (C, I, T)
Compression presses: 15–1 to 150 ton
Injection machines: 5–2 to 24 oz.
Transfer presses: 5–50 to 250 ton; 2–75 ton automatic presses
Pres., Sls. Mgr.–C. W. Kleinderer
Vice Pres.–T. H. Dudley Perkins
Gen. Mgr.–A. A. Dukert
Pur. Agt.–Geo. W. Wilson

***Perry Plastics, Inc., Erie** (C, I, T)
Compression presses: 12–75 to 300 ton
Injection machines: 14–4 to 32"
Transfer presses: 4–150 to 300 ton
Pres.–J. C. Stokes
Vice Pres.–H. H. George
Sls. Mgr. & V.P. Sales–S. C. Seley
Pur. Agt.–H. K. Siegmund

***Plastic Mold & Die Co., Darby** (C, I, T)
Compression presses: 1–75 ton; 1–200 ton
Injection machines: 1–4 oz. vertical
Transfer presses: 1–200 ton
Pres.–J. V. Kohdan
Sls. Mgr.–G. Kirschner

***Plastic Mold & Tool Co., Philadelphia** (C)
Compression presses: 8–15 to 75 ton
Owner–Herman Purner

★**Polymer Corp., The, Reading** (E)
Extrusion machines: 10–from 2" to 4½"
Pres.–Louis L. Stott
Vice Pres., Mfg.–Ralph E. James
Sls. Mgr.–Robert E. Barthold
Pur. Agt.–Alvin S. Mallatratt

***Port Erie Plastics, Inc., Erie** (I)
Injection machines: 7–from 2½ oz. to 32 oz.

***Precision Plastics Co., Philadelphia** (I)
Injection machines: 4 to 24 oz.
Pres.–Edward W. Danien

★**Presque Isle Plastics, Inc., Erie** (I)
Injection machines: 4–4 oz.; 1–8 oz.; 3–12 oz.; 3–16 oz.; 1–22 oz.; 1–32 oz.; 2–48 oz.; 1–90 oz.
Pres.–W. J. Phillips
Secy.-Treas.–D. N. Struble

★***Quinn-Berry Corp., Erie** (I)
Injection machines: 4–4 oz., 11–8 oz., 8–12 oz.
Pres. & Sls. Mgr.–James P. Quinn
Vice Pres., Mfg.–James P. Murphy
Secy. & Treas.–L. L. Berty
Asst. Secy.–E. M. Mulcahy
Pur. Agt.–A. P. Wagner

***Skyline Industries, Titusville** (E, I, T)
Extrusion machines: 22–2½" to 12"
Injection machines: 7–4 oz. to 16 oz.
Transfer presses: 1–50 tons; 1–100 ton
Pres.–Noel J. Poux
Vice Pres.–Richard N. Poux
Sls. Mgr.–C. R. Knouse
Gen. Mgr., Pur. Agt.–Charles A. Poux

Squires Plastics, Inc., Verona (C, T)
Compression presses: 5–from 15 up to 400 tons
Transfer presses: 2–25 to 400 tons
Pres.–W. K. Squires
Vice Pres., Sls. Mgr.–M. K. Meyer
Vice Pres., Sls. Mgr.–M. K. Worstell

Stagg, W. H., Plastics Engineering, Philadelphia (I)
Injection machines: 2 oz., 8 oz.
Pres.–Laura G. Stagg

***Sylvania Electric Products, Inc., Parts Div., Warren** (C, I, T)
Compression presses: 9–15 ton; 13–50 ton; 16–60 ton; 2–150 ton
Injection machines: 1–2 oz.; 1–2½ oz.; 6–4 oz.; 3–8 oz.; 2–12 oz.; 1–20 oz.; 1–48 oz.
Transfer presses: 2–150 ton; 2–200 ton
Pres.–Robert E. Lewis
Vice Pres., Parts Div.–Merle W. Kremer
Sls. Mgr.–F. Martin
Pur. Agt.–R. Marlin

***Vulcanized Rubber & Plastics Co., Morrisville** (I)
Injection machines: 20–3 oz. to 56 oz.
Pres.–Robert G. Werner
Vice Pres., Mfg. & Sls.–David Lewis
Sls. Mgr.–C. C. Freund
Pur. Agt.–Joseph Matteucci

***Westmoreland Plastics Co., Inc., Latrobe** (C)
Compression presses: 24–15 ton to 250 ton; 23 automatics
Pres.–Glenn J. Davis
Vice Pres.–F. M. Schuman
Sls. Mgr.–Harvey G. Skinner
Pur. Agt.–Harry Jardine

***Wirz, A. H., Inc., Chester** (C, I)
Compression presses: 5–50 ton; 2–150 ton
Injection machines: 1–4 oz.; 4–8 oz.
Pres.–R. F. Cox
Vice Pres., Sls. Mgr.–D. B. McAfee
Pur. Agt.–J. E. Smith

Yates Co., Erie (E, I)
Extrusion machines: 5–1" to 3½"
Injection machines: 1–6 oz.
Pres.–R. N. Yates
Vice Pres.–J. O. Elbin
Sls. Mgr.–W. N. Mulkie

RHODE ISLAND

Belon Chemical Co., Inc., Cranston (E)
Extrusion machines: 1–2½"; 1–3½"
Pres., Sales Mgr., Pur. Agt.–Robert M. Kempton
Vice Pres.–Harold M. Foster

***Berkander, George F., Inc., Providence** (E, I)
Extrusion machines: 1
Injection machines: 9–2 oz.; 1–4 oz.; 2–9 oz.
Pres.–John S. Moran
Vice Pres.–Bertin Anderson
Sales Mgr.–Douglas T. Lakey
Pur. Agt.–Steward Fraser

***Cowan Boyden Corp., Providence** (I)
Injection machines: 1–1/3 oz.; 1–2 oz.; 2–4 oz.; 1–5 oz.; 4–8 oz.; 1–12 oz.; 1–16 oz.; 1–20 oz.

Greene Plastics Corp., Hope Valley (C, I)
Compression presses: 10–75 ton
Injection machines: 5 presses to 6 oz.
Pres.–William Blunt White
Sls. Mgr.–Walter F. Cole, Jr.
Pur. Agt.–Francis E. Card

Molding Corp. of America, Inc., Providence (C, T)
Compression presses: 25–up to 300 ton
Transfer presses: 1–60 ton
Pres.–Robert G. Holt
Vice Pres.–Shirley Harrington
Sls. Mgr.–Stephen Kalarian
Pur. Agt.–Sturgis Green

***Plastic Engineering Co., Pawtucket** (I)
Injection machines: 7–2 to 24 oz.
Pres., Sls. Mgr. & Pur. Agt.–Edward I. Rose
Vice Pres.–Beatrice Rose

***Rosbro Plastics Corp., Pawtucket** (I)
Injection machines: 20
Pres.–Bertram M. Brown
Sls. Mgr.–Gregory T. Parkos
Pur. Agt.–Albert M. Surdut

***Tupper Co., Woonsocket** (E, I)
Extrusion machines: 1¼"–6"
Injection machines: 100–2 oz.-48 oz.
Pres.–John R. Ansley
Vice Pres.–Gerald R. Zeek
Sls. Mgr.–Edwin N. Fitzpatrick

SOUTH CAROLINA

Sonoco Products Co., Hartsville (C, E, I, T)

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* Operates own tool room
★ Indicates Advertiser

Compression presses: 58–35 ton; 3–150 ton; 3–200 ton
Extrusion machines: 1–1½"
Injection machines: 1–5 oz.; 2–16 oz.
Transfer presses: 1–150 ton; 1–300 ton; 1–500 ton
Pres.—James L. Coker
Exec. Vice Pres.—Charles W. Coker
Sls. Mgr.—C. H. Campbell
Pur. Agt.—P. C. Coggeshall

***Soo Valley Co.,** Columbia (E)
Extrusion machines: 2–1¾"
Pres.—A. L. Scott
Sls. Mgr.—Robert L. Beebe
Pur. Agt.—Frank Cox

★*Southern Plastics Co., Columbia (C, E)
Compression presses: 7—up to 200 ton
Extrusion machines: 5—from 2½" to 4⅛"
Pres.—J. W. Lindau III
Vice Pres.—Irwin Kahn
Vice Pres., Pur. Agt.—Leonard Boyan

***Westinghouse Electric Corp., Micarta Div.,** Hampton (C, E)
Compression presses: 375–50 ton to 1500 ton
Extrusion machines: 1–2"; 1–6"
Pres.—M. W. Cresap, Jr.
Exec. Vice Pres.—J. K. Hodnette
Marketing Mgr.—H. C. Smith
Pur. Agt.—D. E. Thompson

TENNESSEE

Kusan, Inc., Nashville (I)
Injection machines: 16–2 to 32 oz.
Pres.—W. R. McLain
Vice Pres.—E. C. Horton
Sales V.P.—L. P. Brittain
Pur. Agt.—Charles Griffin

Morgan Plastics, Nashville (I)
Injection machines: 1–9 oz.
Gen. Mgr.—Wills N. Morgan
Sls. Mgr.—E. S. Morgan Jr.

***National Plastics, Inc.,** Knoxville (C, I, T)
Compression presses: 2–150 ton; 2–200 ton; 2–300 ton
Injection machines: 1–1¼ oz.; 1–8 oz.
Transfer presses: 2–150 ton; 2–200 ton; 2–300 ton
Pres.—Chris Van Deventer III
Sls. Mgr.—A. E. Drew
Vice Pres.—Charles L. Yeomans, M. T. Victor

***Patent Button Co. of Tennessee, The,** Knoxville (C, I)
Compression presses: 44–15 to 500 ton
Injection machines: 6–4-28 oz.
Pres.—E. C. Snoddy
Vice Pres.—D. S. Hart
Sls. Mgr.—David G. Adcock
Pur. Agt.—S. E. Cunningham

Plastics Industries, Inc., Athens (I)
Injection machines: 1–6 to 8 oz.
Pres., Sls. Mgr.—J. C. Boone III
Vice Pres.—Roy Nankivell, Jr.
Pur. Agt.—Roy Nankivell, Sr.

TEXAS

Blackwell Plastic Molding Co., Inc., Houston (E, I)
Extrusion machines: 1–2½"
Injection machines: 9–1 to 16 oz.
Pres., Pur. Agt.—L. D. Blackwell
Vice Pres.—R. H. Blackwell
Vice Pres., Sales and Eng.—Jim Pinkston
Sec.-Treas.—Irene Blackwell

***Crown Machine & Tool Co.,** Fort Worth (I)
Injection machines: 10–2 oz. to 6 oz.; 37 special machines
Pres.—William Harrison
Vice Pres., Pro.—Hugh O. Clark, Jr.
Vice Pres., Sls.—William Coughlin
Pur. Agt.—Earl Halvorson

***Doré Company, John L.,** Houston (C)
Compression presses: 2–100 ton; 6–1 to 100 ton; 1–150 ton; 6–400 ton; 1–500 ton; 1–750 ton
Extrusion machines: 1–3½"; 1–1¼"
Pres. & Treas.—John L. Doré
Vice Pres. & Gen. Mgr.—J. S. Bawcom
Sls. Mgr.—Harry I. Thompson, Jr.
Pur. Agt.—Oscar M. Fraley

***Electro Plastics Corp.,** Dallas (C, I)
Compression presses: 2–50 ton
Injection machines: 1–2½ oz.; 1–3 oz.; 1–15 oz.
Pres., Pur. Agt.—Joe Baxt
Vice Pres.—Wayland M. George
Sls. Mgr.—Ronald Harper

Libbert Plastics, Inc., Fort Worth (E, I)
Extrusion machines: 1–1½"
Injection machines: 1–4 oz.; 2–12 to 16 oz.; 1–60 oz.
Pres.—Eugene S. Libbert
Vice Pres.—Glenn Gerlich, Alex Warfield
Pur. Agt.—Glenn Gerlich

Linehan & Co., Dallas (E, I)
Extrusion machines: 5–2½"
Injection machines: 1–6 oz.
Pres.—M. J. Linehan
Sls. Mgr.—J. B. Linehan
Pur. Agt.—M. J. Linehan, Jr.

***Lone Star Plastics Co., Inc.,** Fort Worth (C, I)
Compression presses: 1–12 ton, 1–20 ton, 2–50 ton, 1–200 ton
Injection machines: 1–2½ oz., 1–4 oz., 1–6 oz.
Pres.—Melvin Hare
Vice Pres.—E. H. Swazey
Sls. Mgr.—W. Pat Fralia

Moore Plastics, San Antonio (I)
Injection machines: 1–8 oz.
Owner—Bart Moore

***Nalle Plastics, Inc.,** Austin (E, I)
Extrusion machines: 1–3½"; 1–4½"
Injection machines: 2 oz. to 10 oz.
Pres.—George S. Nalle, Jr.
Vice Pres.—A. B. Nalle
Sls. Mgr.—Galen Simmons

Plastic Engineering & Sales Corp., Fort Worth (C, I)
Compression presses: 1–75 ton
Injection machines: 1

Southwestern Plastic Pipe Co., Mineral Wells (E)
Extrusion machines: 3–3½"; 1–6"

***Tex-Trude, Inc.,** Houston (E, I)
Extrusion machines: 5–2½"
Injection machines: 1–16 oz.
Pres.—Thomas H. Shartle
Vice Pres.—A. B. Keckley
Gen. Mgr., Pur. Agt.—C. M. Nettles
Sls. Mgr.—R. O. Tuxson

***Wyatt's Plastics, Inc.,** Houston (C, T)
Compression presses: 15–20 to 1,000 ton
Transfer presses: 8–200 to 300 tons
Pres.—Walter B. Van Wart
Vice Pres.—C. J. Eckenrod
Sls. Mgr.—R. L. Jarmon
Pur. Agt.—Frank Foster

UTAH

***Rider Engineering & Plastic Co.,** Salt Lake (I)
Injection machines: 1–4 oz. to 6 oz.; 1–9 oz.
Pres.—R. W. Rider
Vice Pres.—B. T. Rider
Pur. Agt.—M. W. Rider

VERMONT

★G-W Plastic Engineers, Inc., Bethel (I)
Injection machines: 3–3 oz.; 1–6 oz.
Pres.—O. A. Westgaard
Vice Pres., Sales Mgr., Pur. Agt.—J. R. Galvin

Manchester Molding Co., Manchester Depot (I)
Injection machines: 8 oz.
Pres.—R. L. Thompson
Vice Pres. & Pur. Agt.—C. R. Ellingwood
Sales Mgr.—H. J. Stratton

VIRGINIA

***Dominion Plastics Co.,** Colonial Heights (I)
Injection machines: 1–3 oz.; 1–8 oz.; 2–16 oz.
Pres.—Jonathan Bryan III
Sls. Mgr.—Lawrence Blake

***Hake Manufacturing Co., Inc.** Roanoke (E)
Extrusion machines: 3–4 oz.; 6–8 oz.; 6–12 oz.
Pres.—George Kissak
Sls. Mgr.—Robert Gayle
Pur. Agt.—M. J. Husa

***O'Sullivan Rubber Corp.,** Winchester (C, E)
Compression presses: 3–29" x 50"
Extrusion machines: 1–400 lbs./hr. sheeting & shape dies
Pres.—Paul Terretta
Vice Pres.—B. B. Waight
Sls. Mgr.—C. Robert Creamer
Pur. Agt.—W. O. Grove

Southeastern Plastics, Inc., Portsmouth (C, I)
Compression presses: 1–75 ton
Injection machines: 4—up to 12 oz.
Pres., Sls. Mgr.—Robert L. Davis
Vice Pres.—C. M. Davenport
Pur. Agt.—George V. Williams

WASHINGTON

***Allied Mfg. Co.,** Seattle (C, I)
Compression presses: 2–300 ton
Injection machines: 1–9 oz. to 12 oz.
Pres. & Pur. Agt.—C. A. Stone
Vice Pres. & Pur. Agt.—B. M. Rucker

Vaupell Industrial Plastics, Seattle (C, I)
Compression presses: 2–150 tons
Injection machines: 1–¾ oz.; 1–4 oz. to 6 oz.; 1–12 oz.
Pres., Sls. Mgr.—L. J. Vaupell, Jr.
Vice Pres.—E. P. Bayley
Pur. Agt.—H. R. Rogers

Western Plastics Corp., Tacoma (E)
Extrusion machines: 2
Pres.—Dale E. Gaeth
Vice Pres., Sls. Mgr.—Ralph L. Morgenthaler
Pur. Agt.—Arlene E. Skattum

WEST VIRGINIA

Plastics by . . . Hoover, Huntington (C)
Compression presses: 1–20 ton; 1–30 ton
Pres., Pur. Agt.—James K. Hoover
Vice Pres.—G. Kingman Crosby
Sls. Mgr.—D. W. Harris

***Wheeling Stamping Co.,** Wheeling (C, I)
Compression presses: 13–50 ton; 10–150 ton
Injection machines: 1–⅓ oz.; 2–2 oz.; 1–3 oz.; 2–8 oz.
Pres.—A. W. Paull, Jr.
Vice Pres., Sec.—A. D. Paull
Sls. Mgr.—C. B. Hart
Pur. Agt.—L. B. Park

WISCONSIN

Chippewa Plastics Co., Div. of Rexall Drug & Chemical Co., Chippewa Falls (E)
Extrusion machines: 13–1½"; 16–2½"; 1–3½"; 4–4⅛"
Pres.—D. R. Williams
Vice Pres., Sls.—R. F. Hrudka
Vice Pres., Prod.—D. M. Nutter
Dir. of Purchasing & Planning—G. W. Dingman

***Evans-Zeier Plastic Co.,** Madison (I)
Injection machines: 2–8 oz.; 1–35 oz.
Partners—D. L. Evans, R. C. Zeier

***Flambeau Plastics Corp.,** Baraboo (E, I)
Extrusion machines: 2: 1–1½"; 1–3¾"
Injection machines: 15–2 oz. to 200 oz.
Pres.—W. R. Sauey
Vice Pres.—N. O. Sauey
Sls. Mgr.—L. K. Sauey
Pur. Agt.—R. C. Nowotny

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* Operates own tool room
★ Indicates Advertiser

***Gisholt Machine Co.**, Madison (C, CM)
Compression presses: 1—50 ton; 2—75 ton; 1—150 ton; 1—200 ton
Pres.—George Johnson
Vice Pres.—Stanley Johnson
Sales Mgr.—Robert Bruce
Pur. Agt.—Freeman Huegel

Lapcor Plastics, Inc., Manitowoc (C, T)
Compression presses: 12—250 to 500 ton
Transfer presses: 3—250 to 350 ton
Pres.—Walter B. Longacre
Vice Pres.—G. J. Platt
Pur. Agt.—P. A. Carew

Lewis Co., G. B., Watertown (C)
Compression presses: 12—50 to 200 ton
Pres.—G. G. Frater
Vice Pres.—Milton Frater, Allen Frater
Pur. Agt.—Arthur J. Killian

***Milwaukee Plastics, Inc.**, Milwaukee (C, I, T)
Compression presses: 8—200 ton to 350 ton
Injection machines: 8 oz. to 90 oz.
Transfer presses: 5—200 ton to 350 ton
Pres.—C. J. Engman
Vice Pres.-Sls. Mgr.—E. P. Altemeier
Vice Pres.—W. J. Oehrlein
Pur. Agt.—C. F. Preston

***National Plasticrafters, Inc., Sub. of National Lock Co.**, Sheboygan (E)
Extrusion machines: 3—2½"; 1—4"
Pres.—J. R. Sommer
Exec. Vice Pres. & Sls. Mgr.—James S. Erkert
Pur. Agt.—Gilbert Wildman

Norco Plastic Inc., Milwaukee (C, I, T)
Compression presses: 12—50 to 1200 ton
Injection machines: 5—4 oz. to 25 oz.
Transfer presses: 5—50 to 500 ton
Pres.—Edward C. Berg
Vice Pres.—R. W. Hageman
Sls. Mgr.—Richard H. Geske
Pur. Agt.—Henry J. Berg

***Peerless Plastics Co. Inc.**, Butler (I)
Injection machines: 2—5 oz.; 1—9 oz.; 2—16 oz.; 1—24 oz.; 1—90 oz.
Pres.—Charles Ortgiesen
Vice Pres.-Sls. Mgr. & Pur. Agt.—Walter J. Nagle

***Pereles Brothers, Inc.**, Milwaukee (I)
Injection machines: 17
Pres. & Treas.—A. A. Pereles
Vice Pres. & Sls. Mgr.—D. M. Stern
Secy.—J. S. Pereles
Pur. Agt.—D. H. Baum

Plymouth Industrial Products, Inc., Sheboygan (I)
Injection machines: 14 from 64 oz. to 1200 oz.
Pres.—A. J. Simmons
Vice Pres.—Wesley Jung, Sr.
Sls. Mgr.—Robert T. Johnson
Pur. Agt.—G. Abler

★***Portage Plastics Co.**, Portage (E)
Extrusion machines: 1—3¼" Hartig, 1—4½" Davis Std.
Pres., Pur. Agt.—W. G. Hamilton
Vice Pres.—Eugene Polmbach
Sls. Mgr.—A. Cimaroli

***Portz Plastics & Fibre Co.**, Milwaukee (C, I)
Compression presses: 2—100 ton; 1—200 ton
Injection machines: 1—4 oz.; 2—8 oz.
Pres., Pur. Agt.—Chas. A. Portz
Vice Pres.—M. Mueller
Sls. Mgr.—R. T. Chop

***Presco Plastics**, Milwaukee (I)
Injection machines: 4—4 oz. to 20 oz.
Pres., Pur. Agt.—E. K. Schroeter
Vice Pres.—L. L. Schroeter
Sls. Mgr.—H. Stanward

★***Sunlite Plastics, Inc.**, Milwaukee (E)
Extrusion machines: 2—3½", 6—2½", 1—1½"
Vice Pres.—Eugene L. Slingluff

Trim Molded Products Co., Inc., Burlington (I)
Injection machines: 2—8 oz.; 2—12 oz.
Pres., Sls. Mgr.—Russell F. Hagen
Vice Pres.—Louis J. Robbers
Sec., Pur. Agt.—Jack Samuels

***Western Coil & Electrical Co.**, Racine (I)
Injection machines: 2—2 oz.; 1—4 oz.; 1—8 oz.; 1—9 oz.
Pres., Sls. Mgr.—W. Turner Lewis
Pur. Agt.—C. F. Hansen

ENGLAND

***British Moulded Plastics, Ltd.**, London (C, E, I)
Compression presses: 196—4 ton to 300 ton; 20—350 ton to 1,500 ton
Extrusion machines: 10—1¼" to 4½"
Injection machines: 30—2 oz. to 32 oz.
Chairman and Managing Dir.—A. A. Duncan

Erinoid, Ltd., London (E)
Extrusion machines: 4—2"; 20—2½" to 4½"
Pres.—D. Kleeman
Sales Mgr.—E. Osborne

ITALY

***Azienda Resine Sintetiche**, Turin (E)
Extrusion machines: 11

***Lazorazione Materie Plastische, S.A.S.**, Turin (E)
Extrusion machines: 35

Laminators, High-Pressure

A. Decorative *B. Industrial*

CALIFORNIA

Aerojet-General Corp., Structural Plastics Div., Azusa
Max. size laminate sheet: 3' square
Max. size molded tubing: 1" to 4½'
Max. size rolled tubing: 18" dia. to 4½'
Standard length tubing: 54"
Specialize in: phenolic, polyester, and epoxy glass molding compounds and laminates.
Personnel: see p. 1163

Chemold Co., Santa Monica (A, B)
Max. size laminate sheet: 49" x 144"
Pres.—K. D. Smith
Vice Pres., Gen. Mgr.—L. R. Dailey
Sls. Mgr.—R. A. Nelson

Crowl Co., Charles, El Monte (A, B)
Max. size laminate sheet: 40" x 72"
Pres., Sls. Mgr., Pur. Agt.—C. A. Crowl
Chge. of Plant Operations—A. L. Summers
Pur. Agt.—Jean R. Blakistone

★**Dumont Corp.**, San Rafael (B)
Max. size laminate sheet: 54" x 112" (moderate pressure)
Max. size rolled tubing: 36" dia. x 50" long (low pressure)
Personnel: see p. 1163

Fortin Plastics, Inc., Van Nuys (B)
Max. size laminate sheet: 22 x 24"
Standard length tubing: 24"-30"
Specialize in: epoxy glass coil forms.
Personnel: see p. 1163

Plastic Age Sales, Inc., Saugus (B)
Max. size laminate sheet: 3' x 4'
Personnel: see p. 1164

Plastics by Chapman, Richmond (A)
Max. size laminate sheet: 10" x 12"
Specialize in: laminating printed items, documents, etc.
Pres.—Harold B. Chapman, Jr.

Polyply Co., San Diego (A, B)
Max. size laminate sheet: 36" x 96"
Pres.—George A. Baker

Sierracin Corp., The, Burbank (A, B)
Max. size laminate sheet: 42" x 72"
Pres.—C. H. Miller
Vice Pres., Sls.—J. E. Slatky
Pur. Agt.—Helen Tyle

★**Swedlow, Inc.**, Los Angeles (A, B)
Max. size laminate sheet: Press made 60" x 130"; continuous max. width—60"
Specialize in: Vacuum metallizing high-temperature laminates; stretched acrylics
Pres.—Dave Swedlow
Vice Pres.—John Endicott
Sls. Mgr.—W. H. Face
Pur. Agt.—R. Affeld

Taylor Fibre Co., La Verne (B)
Max. size laminate sheet: 49 x 49"
Max. size rolled tubing: 0.050" to 26.4" I.D.
Standard length tubing: 48"
Specialize in: Vulcanized fibre and laminated plastics in sheet, rod, tube, and fabricated parts.

CONNECTICUT

★**New England Laminates Co. Inc.**, Stamford (B)
Max. size laminate sheet: 48" x 80"
Pres.—John E. Currier
Sls. Mgr.—Bruce B. Greenfield
Pur. Agt.—Jerome Power

DELAWARE

Continental Can Co., Inc., Conolite Dept., Wilmington (A, B)
Max. size laminate sheet: 36" and 48" wide; continuous length
Sls. Mgr., Decorative—R. E. Fitzgerald
Sls. Mgr., Industrial—J. O. Otis

★**Continental-Diamond Fibre Corp., Subsidiary of The Budd Co.**, Newark (B)
Max. size laminate sheet: 37" x 96" x 10"
Max. size molded tubing: 9½" O.D. x 46" long
Max. size rolled tubing: 56" O.D. x 76" long
Standard length tubing: 46"
Specialize in: electrical grades
Personnel: see p. 1165

Franklin Fibre-Lamitex Corp., Wilmington (B)
Max. size laminate sheet: 24 x 96, 38 x 75, 36 x 36
Max. size molded tubing: 6⅝" O.D.
Max. size rolled tubing: 32¼" O.D.
Standard length tubing: 36" and special long lengths

★ Indicates Advertiser

National Vulcanized Fibre Co., Wilmington (B)
Max. size laminate sheet: 39″ x 47″; 23″ x 90″
Max. size molded tubing: 12¼″
Max. size rolled tubing: 30″
Standard length tubing: 48″
Specialize in: over 75 grades of laminated plastic & combinations with metal foil, rubber, fibre.
Pres.—E. R. Perry
Vict Pres.—F. J. Crow, R. S. Fisher
Sls. Mgr.—J. R. Kallaher
Pur. Agt.—L. R. Clinton

FLORIDA

All-Tech Industries, Inc., Miami (A)
Max. size laminate sheet: 4 x 8
Specialize in: polyester and epoxy.

Plastex Laminates, Inc., Hialeah (A)
Max. size laminate sheet: All sizes; standard to 20′ x 8′
Specialize in: decorative cast/lamination enveloping any core material.
Personnel: see p. 1165

GEORGIA

Lamex, Inc., Norcross (B)
Max. size laminate sheet: 73″ wide
Max. size rolled tubing: 63″ wide
Standard length tubing: Depends on thickness
Personnel: see p. 1165

Magnolia Plastics, Inc., Chamblee
Max. size molded tubing: 1″ diameter (outside)
Specialize in: epoxy.
Pres.—Donald C. Wells
Vice Pres.—Lester E. Hill
Sls. Mgr., Pur. Agt.—R. M. Wells

ILLINOIS

★**Carroll Co., J. B.,** Chicago (A, B)
Max. size laminate sheet: 21″ x 25½″
Specialize in: laminating of printed sheets
Pres., Treas.—J. B. Carroll
Vice Pres., Dir. of Sls.—C. N. Cahill
Sls. Mgr.—M. Sutherland
Pur. Agt.—G. Regas

Felsenthal & Sons, G., Chicago (B)
Max. size laminate sheet: 20 x 20
Personnel: see p. 1165

Richardson Co., The, Melrose Park (B)
Max. size laminate sheet: 49″ x 59″
Max. size molded tubing: 2″ O.D.
Max. size rolled tubing: 12″ I.D.
Standard length tubing: 36″ and 48″
Specialize in: NEMA grades of laminates for electrical and mechanical products; sheets, rod, tubes, and fabricated parts.
Personnel: see p. 1166

IOWA

Farley & Loetscher Mfg. Co., Plastics Division, Dubuque (A, B)
Max. size laminate sheet: Decorative: 36″ x 72″; 48″ x 60″; industrial: 36″ x 84″; 48″ x 60″ paper grades; 36″ x 84″ fabric grades
Pres.—J. M. Burch, Jr.
Vice Pres.—A. E. Loetscher
Div. Mgr.—F. R. Loetscher
Pur. Agt.—L. J. Streinz

MARYLAND

Englander Co., The, Industrial Plastics Div., Baltimore (B)
Max. size laminate sheet: 5′ x 8′
Specialize in: rigid urethane foam.
Pres.—Ira M. Pink
Vice Pres., Gen. Mgr., & Sales Mgr.—Mitchell A. Kapland
Pur. Agt.—Thomas Russe

Malco Plastics, Inc., Baltimore (A, B)
Max. size laminate sheet: 21″ x 25″
Pres.—L. Lawrence
Vice Pres., Sls. Mgr.—H. Verbit
Pur. Agt.—R. Daniel

★**National Plastic Products Co., The,** Odenton (A)
Max. size laminate sheet: 48″ x 120″
Personnel: see p. 1167

MASSACHUSETTS

★**Blank, Arthur, & Co., Inc.,** Boston (A, B)
Max. size laminate sheet: 21½″ x 51½″
Pres., Pur. Agt.—Arthur Blank
Vice Pres.—Harry Blank
Sls. Mgr.—Bernard A. Blank

Bolta Products Div., The General Tire & Rubber Co., Lawrence (A)
Specialize in: serving trays.
Personnel: see p. 1167

Colorvision Plastics, Inc., Boston (A)
Max. size laminate sheet: 37″ x 73″
Pres., Sls. Mgr.—J. J. Donovan

Parkwood Laminates, Inc., Wakefield (A, B)
Max. size laminate sheet: 48 x 120
Pres. & Sls. Mgr.—Sherman R. Thayer
Vice Pres.—P. B. Leverette
Pur. Agt.—Vivian Aston

Plastic Industrial Products, Div. of Carlon Products Corp., Somerville
Max. size molded tubing: ⅛″ to 12″

Reiss Associates, Lowell (A)
Max. size laminate sheet: 48 x 120
Specialize in: decorative laminates; hardboard laminates.
Pres.—E. Reiss
Vice Pres., Sls. Mgr.—A. M. Reiss
Pur. Agt.—A. Cornez

Standard Pyroxoloid Corp., Leominster (A)
Max. size laminate sheet: 52″ x 22″
Specialize in: laminates of nitrate sheeting (optical, etc.).
Pres., Pur. Agt.—Norman H. Farr
Vice Pres., Treas.—William H. Lane
Sls. Mgr.—Philip J. Mahan

Victory Plastics Co., Hudson (A, B)
Max. size laminate sheet: 60″
Max. size molded tubing: 10″
Personnel: see p. 1168

MICHIGAN

Acme Laminating & Plastics Co., Inc., Detroit (A)
Max. size laminate sheet: 24″ x 24″
Pres.—J. D. Keiswetter
Vice Pres.—Mark Berke
Sls. Mgr.—Verne Sorgo
Pur. Agt.—H. Ristum

Duralastic Products Company, Detroit (A, B)
Max. size laminate sheet: 36″ x 72″
Personnel: see p. 1168

★**Fabricon Products, Inc.,** River Rouge (A)
Max. size laminate sheet: 4′ x 10′
Personnel: see p. 1168

Leon Chemical Industries, Inc., Warren (A, B)
Max. size molded tubing: 8″ outside diameter, ¼″ wall thickness
Standard length tubing: 10′ long for tubes from 1″ to 3½″, 6′ long for tubes 4″ to 8″
Specialize in: small diameter tubing for automatic molds.
Pres., Pur. Agt.—Arthur S. Nichols
Vice Pres., Sls. Mgr.—Robert Cox

Reynolds Plastics, Inc., Walled Lake (A, B)
Max. size laminate sheet: 24 x 22
Personnel: see p. 1169

St. Regis Paper Co., Panelyte Div. Kalamazoo (A)
Max. size laminate sheet: 48″ x 120″
Specialize in: decorative sheet.

Woodall Industries, Inc., Detroit (A)
Max. size laminate sheet: 48″ x 19″
Specialize in: decorative surfaced thermoplastic and thermosetting laminated sheet.
Personnel: see p. 1169

MISSOURI

Consolidated Plastic Sales Co., St. Louis (A)
Max. size laminate: 24″ x 36″
Pres.—Leroy C. Germain

NEW JERSEY

Coating Products, Inc., Englewood (A)
Pres.—M. M. Mainthow
Vice Pres.—R. H. Goodman
Sls. Mgr.—J. Abrams
Pur. Agt.—J. Farley

★**Davis Plastics Co., Joseph,** Kearny (A, B)
Max. size laminate sheet: 22″ x 52″
Personnel: see p. 1170

Efka Plastic Corp., Hoboken (A)
Max. size laminate sheet: 23½″ x 53½″
Personnel: see p. 1195

★**Emeloid, Co., Inc., The,** Hillside (A, B)
Max. size laminate sheet: 21½″ x 25½″ (4 laminating presses, 22″ x 26″)
Personnel: see p. 1170

Kaykor Industries, Inc., Yardville (A, B)
Max. size laminate sheet: 48″ x continuous length
Personnel: see p. 1195

Polyplastex United, Inc., Union (A, B)
Max. size laminate sheet: 48″ x 96″
Personnel: see p. 1171

St. Regis Paper Co., Panelyte Div., Trenton (B)
Max. size laminate sheet: 36″ x 36″; 36″ x 48″; 36″ x 72″; 36″ x 78″; 48″ x 60″; 48″ x 96″
Max. size molded tubing: 5½″
Max. size rolled tubing: 24″
Standard length tubing: 36″, 48″, and 96″
Specialize in: laminated sheet, tube, rod; fabricated parts.

Spiral-Glas Pipe Co., Old Bridge (B)
Max. size molded tubing: 6″ I.D.
Standard length tubing: 20′
Specialize in: piping for chemical process and oil field markets
Pres.—Carl de Ganahl
Sls. Mgr.—C. Brice de Ganahl
Pur. Agt.—Amy MacKenzie

Young Development Div., Explosives Dept., Hercules Powder Co., Rocky Hill (B)
Max. size laminate sheet: 24″ x 24″
Max. size molded tubing: 3″
Specialize in: custom molding.
Personnel: see p. 1172

NEW YORK

Aacon Industries, Inc., Brooklyn (A, B)
Max. size laminate sheet: 48″ x 72″
Specialize in: all thermoplastics.
Personnel: see p. 1172

Fersons Industries, Inc., New York (B)
Max. size laminate sheet: 24″ x 54″
Personnel: see p. 1195

Industrial Sales Engineers, N. Y. (A, B)
Max. size laminate sheet: 24″ x 36″
Max. size molded tubing: 6″
Standard length tubing: 6 ft.
Specialize in: custom work only.
Personnel: see p. 1173

★ Indicates Advertiser

Laminated Fiberglass Corp. of America, New York (A, B)
Max. size laminate sheet: 48" x 168"
Pres.—Moosa Haghani
Vice Pres.—L. Haghani
Sls. Mgr.—F. Savastano
Pur. Agt.—Arnold Siegel

Lewis, J. P., Co., The, Plastic Products Div., Beaver Falls (A, B)
Max. size laminate sheet: 40 x 60; 40 x 42
Specialize in: low-cost electrical grade laminates and custom map and chart decorative laminates.
Pres.—J. P. Lewis
Gen. Mgr.—J. C. Parsell

Lumar Optical Mfg. Co., Inc., Mount Vernon (A, B)
Max. size laminate sheet: 18" x 18"
Pres., Sls. Mgr., Pur. Agt.—Martin S. Fox
Vice Pres.—Ludwig Geist

Mica Insulator, Div. of Minnesota Mining & Mfg. Co., Schenectady (A, B)
Max. size laminate sheet: 36" x 42"
Max. size molded tubing: diameter 3"; length 40"
Max. size rolled tubing: 12" O.D.
Standard length tubing: 38"
Specialize in: glass bases for industrial grades and decorative grades for engraving.

Plastic Service Corp., New York (A, B)
Max. size laminate sheet: 23½ x 53½
Pres.—William Kaplan
Vice Pres.—Paul Worthrimer
Sls. Mgr.—Ben Massler
Pur. Agt.—William Kaplan

Printloid, Inc., Long Island City (B)

Printon Corp., New York (A, B)
Max. size laminate sheet: 56" x 72"
Personnel: see p. 1196

Rudd Plastic Fabrics Corp., Brooklyn (A, B)
Max. size laminate sheet: 24" x 54"
Personnel: see p. 1196

Spaulding Fibre Co., Inc., Tonawanda (B)
Maz. size laminate sheet: 41" x 49"
Max. size rolled tubing: 6" diameter
Standard length tubing: 37"
Specialize in: vulcanized fibre, industrial laminates, and fabricated parts.
Pres.—C. C. Steck
Vice Pres.—E. C. Knobloch
Sls. Mgr.—W. R. Gilsdorf
Pur. Agt.—W. L. Grieser

Teitelbaum Sons, N., Inc., New York (B)
Max. size laminate sheet: 54" x 120"
Pres.—J. Teitelbaum
Vice Pres.—F. Leibowitz
Sls. Mgr.—B. Schwartz
Pur. Agt.—Joe Taylor

OHIO

Apex Reinforced Plastics Div., White Sewing Machine Corp., Cleveland (A, B)
Max. size molded tubing: 21" dia., 12' long
Specialize in: high strength, filament wound structures, and pressure vessels.
Pres.—Edward S. Reddig
Vice Pres.—John A. Gehling
Sls. Mgr.—William Patterson
Pur. Agt.—John Clyne

Dobeckmun Co., The, Div. of The Dow Chemical Co., Cleveland (A, B)
Specialize in: special laminations of paper, film and foils.
Personnel: see p. 1196

Formica Corp., The, Cincinnati (A, B)
Max. size laminate sheet: decorative: 48 x 96; industrial: 48 x 120
Max. size molded tubing: O.D. up to 3"
Max. size rolled tubing: O.D. up to 18"
Standard length tubing: 36"

General Electric Co., Laminated Products Dept., Coshocton (A, B)
Max. size laminate sheet: Decorative—48" x 120" nominal; industrial—36" x 72" nominal
Max. size molded tubing: O.D. 3.875"
Max. size rolled tubing: O.D. 13", I.D. 10"
Standard length tubing: 36" nominal
Specialize in: general-purpose decorative, postforming decorative, electronic-grade industrial, and copper clad industrial.
Gen. Mgr.—D. A. Hopper
Mkting Mgr. of Decorative Prod. Sales—B. W. Bullock
Mgr., Industrial Laminate Sales—B. F. Brehl
Pur. Agt.—N. L. Harris

★Seiberling Rubber Co., Plastics Div., Newcomerstown (B)
Max. size laminate sheet: 60" x 102"
Personnel: see p. 1175

OKLAHOMA

Fibercast Co., Sand Springs (B)
Max. size molded tubing: 2⅜" O.D.;-2⅞" O.D.; 3½" O.D.-4½" O.D.
Standard length tubing: 20'-6"
Pres.—George McCuskey
Gen. Mgr.—H. D. Boggs
Sls. Mgr.—Jerry Hutchison
Pur. Agt.—Jack Woods

PENNSYLVANIA

Allegheny Plastics, Inc., Coraopolis (A, B)
Max. size laminate sheet: 24" x 30"
Specialize in: printed laminates, slide rules, charts, computers, etc.
Personnel: see p. 1175

Curry Arts, Scranton (A, B)
Max. size laminate sheet: 36" x 36"
Specialize in: acrylic decorative sheets, acrylic and wood building panels.
Personnel: see p. 1176

★Laminations, Inc., Scranton (A, B)
Max. size laminate sheet: 54" x 54"
Pres.—John R. Muldowney
Vice Pres.—M. J. Lynch

Penn-Plastics Corp., Glenside (B)
Specialize in: all types laminates, phenolic, silicone, glass, etc. for industrial field.
Personnel: see p. 1176

Plastic Laminating Co., Swarthmore (A, B)
Max. size laminate sheet: 23¾" x 31"
Specialize in: graphic products.
Personnel: see p. 1182

★Scranton Plastic Laminating Corp., Scranton (A)
Max. size laminate sheet: 18" x 24"; 36" x 48"; 50" x 108"
Personnel: see p. 1196

Synthane Corp., Oaks (B)
Max. size laminate sheet: 36 x 36, 36 x 72, 24 x 96
Max. size molded tubing: 4" O.D.
Max. size rolled tubing: 26½" O.D.
Standard length tubing: 36"-48"-96"
Specialize in: custom fabricated laminated plastics.
Pres.—R. R. Titus
Mgr., Sls. Promotion and Customer Relations—Herbert Widdop
Pur. Agt.—C. H. Cox, Jr.

Taylor Fibre Co., Norristown (B)
Max. size laminate: 49 x 49
Max. size molded tubing: 4" O.D.
Max. size rolled tubing: 0.125" to 10.5" I.D.
Standard length tubing: 48"
Specialize in: vulcanized fibre and laminated plastics in sheet, rod, tube, and fabricated parts.
Pres.—J. M. Taylor, Jr.
Vice Pres., Sls.—E. H. DaCosta
Sls. Mgr.—P. A. Slaughter
Pur. Agt.—H. R. Fifer

Willson Camera Co., Havertown (A)
Max. size laminate sheet: 22" x 50"
Pres.—Thomas C. Willson
Vice Pres.—Russel Onspack
Sls. Mgr.—R. Jones
Pur. Agt.—N. Boks

SOUTH CAROLINA

Westinghouse Electric Corp., Micarta Div., Hampton (A, B)
Max. size laminate sheet: 30 x 120; 48 x 96
Max. size rolled tubing: up to 60" O.D. and to 72" length
Standard length tubing: 18, 24, 36, 48"
Personnel: see p. 1177

TENNESSEE

Plastics Industries, Inc., Athens (A)
Max. size laminate sheet: 6" x 8"
Personnel: see p. 1177

TEXAS

Lone Star Plastics Co., Inc., Ft. Worth (B)
Max. size laminate sheet: 24" x 24"
Specialize in: special shapes, silicone and fibrous glass laminates.
Personnel: see p. 1177

WASHINGTON

Pacific Plastics Co., Seattle (B)
Max. size laminate sheet: 48" x 96"
Pres., Sls. Mgr.—Ben Rosen
Vice Pres.—Al Rosen
Pur. Agt.—Jean Roache

Vaupell Industrial Plastics, Seattle (B)
Max. size laminate sheet: 1—16" x 12"; 1—20" x 30"
Personnel: see p. 1177

WISCONSIN

Bostrom Corp., Milwaukee 4, Wis. (A, B)
Maximum size laminate sheet: 20' x 10'
Pres.—Harold Bostrom
Sls. Mgr.—James J. Gibbons
Pur. Agt.—Ed Weiland

Buckstaff Co., The, Oshkosh (A)
Max. size laminate sheet: 3' x 8'
Specialize in: hardboard surfaced with melamine laminate on frame construction.
Pres.—J. D. Buckstaff
Vice Pres.—Clyde Buckstaff
Sales Mgr., Plastics—M. W. Poeschl
Pur. Agt.—M. L. Kaspar

Consoweld Corp., Wisconsin Rapids (A)
Max. size laminate sheet: 60" x 144"
Pres.—S. W. Mead
Sls. Mgr.—J. A. Davies
Pur. Agt.—V. Krapfel

★Decar Plastics Corporation, Middleton (A)
Max. size laminate sheet: 3' x 8' and 4' x 6'
Pres., Sls. Mgr.—Ralph L. Fossier
Vice Pres., Tech. Dir.—T. Walter Noble
Vice Pres., Plant Mgr.—George W. Johnson
Pur. Agt.—Robert Keller

Fiberesin Plastics Co., Oconomowoc (A, B)
Max. size laminate sheet: 48" x 96"
Specialize in: fabricated parts of decorative laminated board and panel stock
Pres.—W. W. Turner
Sls. Vice Pres.—Robert W. Healy
Prod. Vice Pres.—R. J. Lyman

Gisholt Machine Co., Madison (A, B)
Max. size laminate sheet: 4' x 8'
Specialize in: custom molding.
Personnel: see p. 1178

Northern Plastics Corp., La Crosse (B)
Max. size laminate sheet: 39" x 72"
Specialize in: NEMA grades & special laminates for unusual applications.
Pres.—James S. Gelatt
Vice Pres. & Sls. Mgr.—George C. Kroening
Pur. Agt.—S. L. Noe

Presco Plastics, Milwaukee (B)
Pres., Pur. Agt.—E. K. Schroeter
Vice Pres.—L. L. Schroeter
Sls. Mgr.—H. Stanward

★ Indicates Advertiser

Laminators, Thermoplastics

CALIFORNIA

Airconductors, Gardena
Laminate vinyl to vinyl; laminate acrylics to acrylics
Pres.—Fred E. Sindars
Vice Pres.—Mr. Cairns
Sls. Mgr.—J. M. Davis
Pur. Agt.—H. B. Sindars

Crowl Co., Charles, El Monte
Laminate: Thermoplastic to metal and wood; thermosetting to hard board
Personnel: see p. 1178

Plastics by Chapman, Richmond
Laminate: Vinyl to vinyl; acetate to acetate; acrylic to acrylic
Personnel: see p. 1178

Sierracin Corp., The, Burbank
Laminate: Acrylic to acrylic; polyester to acrylic; polyester to polyester
Personnel: see p. 1178

Urrite Plastics Fabricators, Pico Rivera
Laminate: Acrylic to acrylic
Pres.—E. V. Steele

CONNECTICUT

Ross & Roberts, Inc., Stratford
Laminate: Vinyl to vinyl; vinyl to non-woven; vinyl to paper
Pres.—Arthur M. Ross, Jr.
Vice Pres.—Alvin V. Robert
Pur. Agt.—William E. Devine

Rowland Products, Inc., Kensington
Laminate: Cellulose nitrate to cellulose nitrate; cellulose acetate to cellulose acetate; cellulose nitrate, cellulose acetate to metal, cloth
Personnel: see p. 1165

GEORGIA

Lamex, Inc., Norcross
Laminate: Polyethylene to paper, board, cloth, foil, burlap, and cellophane
Personnel: see p. 1165

ILLINOIS

★**Carroll Co., J. B.,** Chicago
Laminate: Vinyl to vinyl; ethyl cellulose to paper; styrene to styrene
Personnel: see p. 1179

Felsenthal & Sons, G., Chicago
Laminate: Acetate to acrylic; vinyl to acrylic; polystyrene to acrylic
Personnel: see p. 1165

Sun Steel Co., Chicago
Laminate: vinyl to steel; laminate vinyl to aluminum; laminate vinyl to magnesium
Pres.—Col. B. G. Kaplan
Vice Pres.—Robert Kaplan
Mgr. Special Prod.—E. N. Sienko

Therm-O-Form Plastics Co., Homewood
Laminate: Vinyl to vinyl; vinyl to paper; vinyl to cardboard
Partner—Donald A. Stolzenbach
Partner—W. Robert Brown

MARYLAND

Malco Plastics, Inc., Baltimore
Laminate: Vinyl to vinyl; butyrate to butyrate
Personnel: see p. 1170

★ Indicates Advertiser

MASSACHUSETTS

★**Blank & Co., Inc., Arthur,** Boston
Laminate acetate to acetate; laminate vinyl to vinyl; laminate flexible vinyls to flexible vinyls
Personnel: see p. 1179

Bolta Products Div., The General Tire & Rubber Co., Lawrence
Laminate: ABS to ABS; PVC to PVC
Personnel: see p. 1167

Flexcon Co., Spencer
Laminate: Vinyl to fabric; Mylar to vinyl; Mylar to styrene
Pres. & Pur. Agt.—Roger Plourde
Sls. Mgr. & Pur. Agt.—Myles McDonough

Leathertone, Inc., Boston
Laminate: Thermoplastics to thermoplastics, paper, wood, metal, etc.
Pres., Pur. Agt.—Jules H. Rubenstein
Vice Pres.—L. Gradone
Sls. Mgr.—Louis Rubenstein

Ludlow Papers, Inc., Plastics Div. Needham Heights
Laminate: Polyolefins to paper, paperboard, fabrics
Personnel: see p. 1195

MICHIGAN

Acme Laminating & Plastics Co., Inc., Detroit
Laminate vinyl to paper 2 sides; laminate vinyl to duron; laminate vinyl to vinyl
Personnel: see p. 1179

★**Fabricon Products, Inc.,** River Rouge
Personnel: see p. 1168

Kal Plastics Inc., Beaverton
Laminate: High-impact styrene to oriented polystyrene
Personnel: see p. 1169

Reynolds Plastics, Inc., Walled Lake
Laminate: Fibrous glass to polyester, epoxy
Personnel: see p. 1169

Woodall Industries, Inc., Detroit
Laminate: Styrene to styrene; vinyl to ABS
Personnel: see p. 1169

MINNESOTA

Perma Seal Plastic Products Co., St. Paul
Laminate: Vinyl to vinyl; polyester to polyester
Pres., Pur. Agt.—Ralph H. Oby

Schjeldahl Co., G. T., Northfield
Laminate: Polyester to other plastics, metals, ceramics
Pres.—Gilmore T. Schjeldahl
Sls. Mgr.—John S. McClintock
Pur. Agt.—Lowell T. Stoutland

MISSOURI

Consolidated Plastic Sales Co., St. Louis
Laminate: Acetate to acetate; acetate to wood
Personnel: see p. 1179

NEW JERSEY

★**Davis Plastics Co., Joseph,** Kearny
Laminate: Cellulose acetate to cellulose acetate
Personnel: see p. 1170

Efka Plastic Corp., Hoboken
Laminate: Plastic to plastic; plastic to cotton
Personnel: see p. 1195

★**Emeloid Co., Inc., The,** Hillside
Laminate: Vinyl to vinyl; styrene to styrene; acetate to acetate
Personnel: see p. 1170

Kaykor Industries, Inc., Yardville
Laminate: Vinyl to vinyl; vinyl to cloth; vinyl to glass
Personnel: see p. 1195

Lamart Corp., Clifton
Laminate: Mylar to vinyl, paper, fabric; vinyl to vinyl, paper, fabric
Pres.—Walter B. Hirsh
Vice Pres.—Joseph Zamer
Pur. Agt.—John Le Schievo

Modular Molding Corp., Burlington
Laminate: Vinyl, mylar, etc., to metal, plywood; fibrous glass to foam, plywood, and honeycomb cores
Personnel: see p. 1171

Plastex Process Co., Maywood
Laminate: Nylon to narrow fabrics or foil, 4" maximum width
Personnel: see p. 1171

Plastic Laminating Corp., Vauxhall
Laminate vinyl to vinyl; laminate acetate to acetate; laminate vinyl to acrylic
Pres., Sls. Mgr.—Joseph Di Bella
Vice Pres—Vincent T. Cooney
Pur. Agt.—Terry Kane

Polyplastex United, Inc., Union
Laminate vinyl to vinyl, paper foil; laminate acrylic to acrylic, vinyl; laminate styrene to styrene, paper foil
Personnel: see p. 1171

Resistoflex Corp., Roseland
Laminate: Teflon to glass cloth
Pres.—E. S. Peierls
Vice Pres.—H. E. Krebs
Sls. Mgr.—H. H. Wulff

Rich-Tex, Inc., Cedar Grove
Laminate Vinyl to vinyl; Mylar to vinyl; fibrous glass cloth
Pres.—Ray S. Ritchie
Vice Pres., Pur. Agt.—Harry F. Koolen
Sls. Mgr., Secy.—Roy W. Ritchie

Ridge Printing Co., Inc., Ridgefield
Laminate: Vinyl to glass mat; Mylar to glass, vinyl; fabric to vinyl; vinyl to nylon to vinyl, etc.
Personnel: see p. 1195

Rotobond Co., Bound Brook
Laminate polyester film to metal; laminate polyester film to paper; laminate polyester film to hard board
Pres., Sls. Mgr.—R. K. Newcomb
Vice Pres., Pur. Agt.—C. D. Hansen

Roysons, Inc., Cedar Grove
Laminates: Vinyl sheet, film to vinyl sheet, film; Mylar to vinyl sheet, film; cloth, glass cloth to vinyl sheet, film
Pres.—Roy S. Ritchie
Vice Pres., Pur. Agt.—Harry F. Koolen
Sec., Sls. Mgr.—Roy W. Ritchie

NEW YORK

A.A.A. Plastic Co., New York
Laminate: Vinyl to vinyl; acetate to acetate; styrene film to high-impact styrene sheets
Personnel: see p. 1172

Aacon Industries, Inc., Brooklyn
Laminate rigid vinyl to vinyl; laminate rigid acetates to acetates; laminate rigid polystyrene to polystyrene; laminate rigid acrylic to acrylic
Personnel: see p. 1172

★Auburn Plastics, Inc., Auburn
Laminate: Polystyrene film to styrene copolymers
Personnel: see p. 1172

Barr Corp., The, Richmond Hill
Laminate: Polyvinyl chloride to woven and non-woven fabrics; Polyvinyl chloride to polyvinyl chloride; polyvinyl chloride to Mylar
Pres., Sls. Mgr.—Irvin S. Kramer
Vice Pres.—Sanford Bayer
Treas., Pur. Agt.—Martin B. Bayer

Brulene Coated Textiles, Inc., Brooklyn
Laminate: Film to fabric; film to film; film to paper
Personnel: see p. 1195

Elm Coated Fabrics Co., Inc., New York
Laminate: Vinyl to vinyl; vinyl to cloth; vinyl to paper
Personnel: see p. 1195

Fabric Leather Corp., New York
Laminate: vinyl to vinyl; laminate vinyl to cotton
Personnel: see p. 1195

Fassler & Co., Inc., M. J., Brooklyn
Laminate: Film to paper; film to fabric; film to film
Personnel: see p. 1195

Fersons Industries, Inc., New York
Laminate vinyl to vinyl
Personnel: see p. 1195

Harte & Co., Inc., New York
Laminate: Vinyl to fabric
Personnel: see p. 1195

★Hopp Plastics, Div. of the Hopp Press, Inc., New York
Laminate: Vinyl to vinyl; vinyl to paper; vinyl to fabric
Personnel: see p. 1173

Industrial Sales Engineers, New York
Laminate: Vinyl to vinyl; acetate to acetate; styrene to high-impact styrene
Personnel: see p. 1173

Lumar Optical Mfg. Co., Mount Vernon
Laminate: Acrylic to acrylic
Personnel: see p. 1180

Marbek, Inc., Brooklyn
Laminate: Vinyl to all fabrics; vinyl to vinyl; vinyl to miscellaneous materials
Personnel: see p. 1195

Metallic Plastics Corp., Long Island City
Laminate: vinyl to vinyl; Mylar to vinyl; paper to vinyl
Personnel: see p. 1195

Pearson Industries, Long Island City
Laminate: Vinyl to vinyl; Mylar to vinyl; paper to vinyl
Personnel: see p. 1196

Plastic Center, Rochester
Laminate: Acrylic to acrylic; vinyl to vinyl, paper, wood, etc.; butyrate to butyrate, paper, wood, etc.
Pres.—O. Dudley Ward
Vice Pres., Pur. Agt.—John W. Proctor

Plastic Service Corp., New York
Laminate: vinyl to vinyl; laminate vinyl to fabrics, wood; laminate vinyl to duron, metal
Personnel: see p. 1180

Printloid, Inc., Long Island City
Laminate: Vinyl to vinyl; acetate to vinyl

Printon Corp., New York
Laminate: Paper to paper, aluminum foil or films; films to aluminum foil; films; fabrics; paper
Personnel: see p. 1196

Rudd Plastic Fabrics Corp., Brooklyn
Laminate: vinyl to non-woven material; laminate: vinyl to vinyl; laminate: vinyl to all backed materials
Personnel: see p. 1196

Superior Laminating Co., New York
Laminate: Acrylics to acrylics; acrylics to vinyl
Pres.—Edward Rosner

Teitelbaum Sons, Inc., N., New York
Laminate vinyl to vinyl; laminate acetate to acetate
Personnel: see p. 1180

Thompson Air Plastics, Mineola
Laminate: vinyl to vinyl

Velveray Corp., New York
Laminate: Vinyl to cotton, nylon, and paper

Virginia Plak Co., New York
Laminate: Vinyl to paper, vinyl, board, and cloth

Weblon, Inc., New York
Laminate plasticized vinyl to fibrous glass; laminate plasticized vinyl to Dacron; laminate plasticized vinyl to nylon
Pres.—S. L. Chambers
Vice Pres.—Robert F. Buehler
Vice Pres.—Robert Rose

OHIO

Dobeckmun Co., The, Div. of The Dow Chemical Co., Cleveland
Specialize in special laminations of paper, film, and foils

PENNSYLVANIA

Allegheny Plastics, Inc., Coraopolis
Laminate: Vinyl to vinyl; acetate to acetate
Personnel: see p. 1175

Contour Packaging Co., Philadelphia
Laminate: Plastic to cardboard
Pres., Sls. Mgr.—Richard A. Tilghman
Vice Pres., Pur. Agt.—Stockton A. Andrews

Curry Arts, Scranton
Laminate acrylic to vinyl; laminate vinyl to wood; laminate acrylic and others to wood, masonite, hardboard, etc.
Personnel: see p. 1176

Firestone Plastics Co., Pottstown
Laminate: Vinyl to vinyl
Personnel: see p. 1196

H & R Industries, Nazareth
Laminate: Polyethylene to various materials; nylon to various materials

★Laminations, Inc., Scranton
Personnel: see p. 1180

Plastic Laminating Co., Swarthmore
Laminate vinyl to vinyl; laminate vinyl to paper
Sls. Mgr. and Pur. Agt.—Samuel M. Dodd, Jr.

★Scranton Plastic Laminating Corp., Scranton
Laminate: Vinyl to vinyl; acetate to acetate
Personnel: see p. 1196

United Laminations, Inc., Mayfield
Laminate: Vinyl to cloth; vinyl to paper prints; vinyl to fibrous glass
Pres., Sls. Mgr.—M. Brog
Vice Pres., Pur. Agt.—H. Perry

Willson Camera Co., Havertown
Laminate: Vinyl to vinyl; vinyl to paper; cellulose acetate to paper
Personnel: see p. 1180

TENNESSEE

Plastics Industries, Inc., Athens
Laminate: vinyl to vinyl; laminate acrylic to acrylic; laminate acetate to acetate
Personnel: see p. 1177

TEXAS

Electro Plastics Corp., Dallas
Laminate: Vinyl to vinyl; butyrate to butyrate, wood
Personnel: see p. 1177

VIRGINIA

O'Sullivan Rubber Corp., Winchester
Laminate: PVC sheeting to steel; PVC sheeting to aluminum; PVC sheeting to hard board
Personnel: see p. 1177

WASHINGTON

Rainier Plywood Co., Tacoma
Laminate: Plastics to wood
Pres.—George F. Baum
Vice Pres.—A. S. Johnson
Sls. Mgr., Plastic Div.—John E. Cowman
Pur. Agt.—Hill Woodard

WISCONSIN

★Portage Plastics Co., Portage
Laminate: oriented styrene to polystyrene
Personnel: see p. 1178

Presco Plastics, Milwaukee
Laminate acetate to other materials; laminate vinyls to other materials
Personnel: see p. 1178

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(For complete addresses, see Alphabetical Index, p. 1214)

Reinforced Plastics Processors

CALIFORNIA

Aerojet-General Corp., Structural Plastics Div., Azusa

Types of molding done and kind of molds used: matched molds, transfer molds, vacuum bag molding, filament winding
Types of resin and reinforcement used: resins: polyesters, epoxy, and phenolics. Reinforcements: glass roving and mat and asbestos
Number of presses, platen area, and daylight space of each press: 1—20 ton, 9 x 12 platen, 6 daylight; 1—35 ton, 18 x 18 platen, 10 daylight; 1—45 ton, 9 x 12 platen, 8 daylight; 1—50 ton, 12 x 12 platen, 10 daylight; 1—50 ton, 18 x 18 platen, 12 daylight; 1—200 ton, 24 x 24 platen, 20 daylight; 2—240 ton, 36 x 36 platen, 36 daylight; 1—300 ton, 36 x 36 platen, 36 daylight; 1—680 ton, 40 x 40 platen, 58 daylight; 1—1000 ton, 48 x 48 platen, 102 daylight
Type of fabrication done: Structural reinforced plastics, metal and plastic bonding
Personnel: see p. 1163

Airconductors, Gardena

Types of molding done and kind of molds used: vacuum bag, cello tension wrap, and matched metal mold
Types of resin and reinforcement used: thermal and thermal setting resins; fibrous glass and synthetic fibers reinforcements
Number of presses, platen area, and daylight space of each press: 2
Personnel: see p. 1181

Alsynite Co. of America, San Diego

Types of molding done and kind of molds used: flat and formed sheets
Types of resin and reinforcement used: polyester and phenolic resins; glass mat and cloth, printed fabrics
Number of presses, platen area, and daylight space of each press: max. size: 60" x 102", 19" daylight
Maximum size of flat or corrugated reinforced plastics panel: 40" x 12'
Type of fabrication: Form sandwich panels
Pres.—J. S. Berkson
Vice Pres.—F. X. Ambrose
Exec. Vice Pres., Pur. Agt.—M. F. McNeil
Sls. Mgr.—R. H. Giffin

Automatic Plastic Molding Co., Berkeley

Types of molding done and kind of molds used: matched metal
Types of resin and reinforcement used: polyester and glass
Number and size of preformers: 2 turners
Personnel: see p. 1163

Calfibe Co., Redlands

Types of molding done and kind of molds used: matched die vacuum bag molding; all types of molds
Types of resin and reinforcement used: polyester, phenolic, DAP, epoxy, silicone, and melamine resins; fibrous glass, nylon, and asbestos reinforcements
Number and size of preformers: 1
Number of presses, platen area, and daylight space of each press: 7
Maximum size of flat or corrugated reinforced plastics panel: 44" x 88"
Pres.—H. P. Barnard, Jr.
Vice Pres.—W. M. Jordan
Sales Mgr.—P. B. Fouke, Jr.
Pur. Agt.—L. P. Bowler

Calresin Co., Div. of Knudsen Creamery, Los Angeles

Types of molding done and kind of molds used: compression, wet layup, vacuum bag, and spray gun molding
Types of resin and reinforcement used: glass, jute, and premix. Polyester, phenolic, silicone, melamine, and urea resins
Number and size of preformers: 4
Number of presses, platen area, and daylight space of each press: 16 presses

Chemold Co., Santa Monica

Types of molding done and kinds of molds used: hydraulic press molding on matched metal dies; hand layup on wood, metal, or epoxy mold
Types of resin and reinforcement used: polyester, epoxy, phenolic, and silicone resins: fibrous glass mat and cloth and chopped roving
Number and size of preformers: 1—48" with ancillary oven equipment
Number of presses, platen area, and daylight space of each: 4—75 ton, 3' x 5', 48" daylight; 2—150 ton, 4' x 8', 72" daylight; 1—750 ton, 52" x 144", 40" daylight
Maximum size of flat or corrugated reinforced plastics panel: ribbed panels, 37⅞" x 96"; flat and ribbed panels, 49" x 144"
Type of fabrication done: all types, including routing, drilling, rivet, and bonding operations; custom molding of contoured parts; flat and ribbed building panels and laminated plywood or foam
Personnel: see p. 1178

Chemtron Fiber Glass Co., El Monte

Types of molding done and kinds of molds used: cold molding, vacuum press contact; reinforced plastics, steel, wood, plaster molds
Types of resin and reinforcement used: epoxy, polyester, and phenolic resins; fibrous glass reinforcements
Number of presses, platen area, and daylight space of each press: 1—24 x 24 x 30, 2—48 x 48 x 72, 1—60 x 144 x 24
Maximum size of flat or corrugated reinforced plastics panel: 60" x 144"
Does continuous laminating
Width and thickness of finished laminate: 1/16" x 50"
Types of fabrication done: most types
Pres.—Roy L. Kinch
Vice Pres.—Charles Kuchinsky
Sls. Mgr.—L. C. Hunter
Pur. Agt.—A. R. Kingsley

★Dumont Corp., San Rafael

Types of molding done and kind of molds used: press, autoclave, vacuum bag, and compression molding; low and moderate pressure laminating. Also wet layup
Types of resin and reinforcement used: phenolic, silicone, epoxy, and polyester resins; prepregs and wet layup
Number of presses, platen area, and daylight space of each press: 1—60 ton, 14", 13" x 24"; 1—400 ton, 12", 54" x 112"; 1—60 ton, 36", 24" x 24". 1—200 ton, 96", 50" x 98"; 1—650 ton, 96", 52" x 52"; 1—200 ton, 92", 50" x 50"
Maximum size of flat or corrugated reinforced plastics panel: 54" x 112" press laminated
Type of fabrication done: Routing, drilling, tapping, sawing, etc.
Personnel: see p. 1163

Filon Plastics Corp., El Segundo

Specialize in: glass and nylon fiber-reinforced polyester resin building panels
Sizes: max. width on corrugated panels, 42"; max. width on flat panels, 49"
Thickness: 0.030" to 0.100"
Length: Continuous laminating
Pres.—David S. Perry
Vice Pres., Manufacturing—G. R. Huisman
Vice Pres., Merchandising—L. Feldman
National Sls. Mgr.—A. Zakarian
Pur. Agt.—F. A. Nichols

Fortin Plastics, Inc., Van Nuys

Types of molding done and kinds of molds used: vacuum bag and matched dies
Types of resin and reinforcements used: polyester, epoxy, phenolic, melamine
Number of presses, platen area, and daylight space of each press: 1—50 ton, 20 x 24, 36" daylight; 1—50 ton, 16 x 96, 24" daylight; 1—20 ton, 12 x 18, 12" daylight
Type of fabrication done: routing, drilling, milling, wet/dry sanding, riveting
Personnel: see p. 1163

General Plastics Corp., Los Angeles

Types of molding done and kind of molds used: matched metal dies
Types of resin and reinforcement used: polyester resin; fibrous glass
Number of presses, platen area, and daylight space of each press: 2—250 ton, 50" x 50", 64" daylight; 1—100 ton, 24" x 36", 48" daylight; 2—40 ton, 20" x 28", 36" daylight; 4—25 ton, 14" x 14", 36" daylight
Type of fabrication done: routing, shaping, punching
Personnel: see p. 1163

Gill Corp., M. C., S. El Monte

Types of molding done and kind of molds used: matched metal dies
Types of resin and reinforcement used: Epoxy, phenolic, polyester, silicone, acrylic resins; fibrous glass cloth and mat, cotton, nylon
Number of presses, platen area, and daylight space of each press: 1—72" x 168", 4' daylight, 1 opening; 1—36" x 36", 2' daylight, 3 opening; 1—20" x 38", 2' daylight, 2 opening
Maximum size of flat or corrugated reinforced plastics panel: 72" x 168"
Type of fabrication done: routing, shaping, drilling, sawing

Kimball Manufacturing Corp., San Rafael

Types of molding done and kind of molds used: matched metal, hand lay-up, vacuum, spray gun, premix
Types of resin and reinforcement used: polyester, phenolic, epoxy, resin, fibrous glass, sisal fibers
Number and size of preformers: 2 to 60" diameter
Type of fabrication done: complete assembly—drilling, routing, riveting, bonding
Personnel: see p. 1163

Laminair, Inc., Gardena

Types of molding done and kinds of molds used: vacuum bag; plaster, plastic, and metal molds; also press laminations
Types of resin and reinforcements used: polyester, epoxy, silicone, phenolic
Number of presses, platen area, and daylight space of each press: 1—14 x 14 x 36
Type of fabrication done: route, drill, bonded structures
Pres. & Gen. Mgr.—John W. Love
Vice Pres. & Sls. Mgr.—Stanley Harkins
Pur. Agt. & Sec.-Treas.—Regina Ogden

Marplex Co., El Segundo

Types of molding done and kind of molds used: matched metal molding
Types of resin and reinforcement used: polyester; fibrous glass roving, and mat
Number and size of preformers: 3—to 30"
Number of presses, platen area, and daylight space of each press: 14—to 36" x 50"; daylight, to 48"
Maximum size of flat or corrugated reinforced plastics panel: 2' x 3'—flat
Type of fabricating done: drilling, sanding, cutting; also produce fibrous glass reinforced cylinders and tubing
Specialize in: decorative reinforced moldings for the lighting industry and giftware applications
Pres., Vice Pres., Sls. Mgr.—Erich Marx
Pur. Agt.—Hans Mayer

Mica Corp., The, Culver City

Types of resin and reinforcement used: epoxy; fibrous glass cloth
Number of presses, platen area, and daylight space of each press: 3—22" x 40", 2" daylight; 1—48" x 96", 2" daylight
Max. size of flat or corrugated reinforced plastics panel: 18" x 36"; 20" x 36" standard; up to 36" x 96" special
Type of fabrication done: cutting to size
Pres.—A. Paul Goldman
Vice Pres., Sales Mgr.—Robert T. Toppin
Pur. Agt.—W. Morcumb

Olympic Plastics Co., Inc., Los Angeles

Types of molding done and kind of molds used: vacuum bag and press molding; wooden, plastic, plaster and matched metal molds.
Types of resin and reinforcement used: polyester, silicone, and vinyl resins; glass and sisal reinforcements
Number and size of preformers: 1—36"; 1—48"
Number of presses, platen area, and daylight space of each press: 7 presses, ranging up to platen area 48" x 60", 72" daylight

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Maximum size of flat or corrugated reinforced plastics panel: 44″ x 100″
Type of fabrication done: all types, including routing, shaping, machining, drilling, etc.
Pres.—David Rome
Vice Pres.—D. C. Siteman
Sls. Mgr.—H. M. Rome
Pur. Agt.—J. Borack

Paralite Manufacturing Co., San Diego

Types of resin and reinforcement used: polyester resin and fibrous glass materials
Maximum size of flat or corrugated reinforced plastics panel: 26″ x 300″
Pres., Sls. Mgr.—Davis W. Parker
Vice Pres.—Harold C. Alexander
Pur. Agt.—Vivienne Malone

Plastic Age Sales, Inc., Saugus

Types of molding done and kind of molds used: vacuum bag molding; plastic, plaster, and metal molds
Types of resin and reinforcement used: polyester, epoxy, and phenolic resins
Number and size of preformers: 1—40″ x 40″; 1—20″ x 20″
Number of presses, platen area, and daylight space of each press: 22: 6 x 6″ to 72″ and 46″ x 82″ platen size, 1″ to 2″ daylight
Type of fabrication done: routing, shaping, drilling, riveting; all assembly processes.
Personnel: see p. 1164

Polyply Co., San Diego

Types of resins and reinforcement used: polyester resin
Number of presses, platen area, and daylight space of each press: 1—40″ x 100—18″
Maximum size of flat or corrugated reinforced plastics panel: 36″ x 96″
Personnel: see p. 1178

Reflin Co., San Deigo

Specialize in: fibrous glass reinforced plastic pipe and fittings, 12″ dia. max. size
Pres., Sls. Mgr.—Louise L. Potomac
Vice Pres.—Lela M. Potomac
Pur. Agt.—L. P. Kehres

Reinhold Engineering & Plastics Co., Norwalk

Types of molding done and kind of molds used: vacuum bag molding with wood, aluminum, and steel molds
Types of resin and reinforcement used: all types of resins and fibrous glass reinforcement
Personnel: see p. 1164

Rippolite Plastic Products, Inc., Burbank

Types of resin and reinforcement used: polyester resin; fibrous glass mat reinforcement
Maximum size of flat or corrugated reinforced plastics panel: flat, 40″ x 12′; corrugated 40″ x 12′
Pres., Sls. Mgr.—Jack D. Whitehead
Vice Pres.—Leo J. Hulbert
Pur. Agt.—James R. Robinson

★Sierra Electric Corp., Gardena

Types of molding done and kind of molds used: matched metal molding and some hand layup; steel, aluminum, plaster, wood and cast plastic molds
Types of resin and reinforcement used: epoxy, phenolic, polyester; fibrous glass mat and asbestos fillers
Number and size of preformers: 2—24″ x 48″
Number of presses, platen area, and daylight space of each press: from 10″ x 10″ to 36″ x 60″ platen; 6″ to 18″ daylight
Type of fabrication done: usual finishing and fabricating operations; manual and special machines
Personnel: see p. 1164

Summit Industries, Inc., Gardena

Types of molding done and kinds of molds used: steel, aluminum, plastic molds
Types of resin and reinforcement used: polyester, epoxy, and silicone
Number and size of preformers: 2
Number of presses, platen area, and daylight space of each press: 6 presses up to 400 ton
Pres.—Albert S. Greenberg
Vice Pres.—Irving Green
Sls. Mgr.—Robert Matlock
Pur. Agt.—Stephen Phillips

★Swedlow, Inc., Los Angeles

Types of molding done and kind of molds used: vacuum bag, matched metal dies
Types of resin and reinforcement used: fibrous fillers, various resins
Number and size of preformers: 1
Number of presses, platen area, and daylight space of each press: 9 presses, maximum daylight 84″; areas 16″ x 18″/60″ x 130″
Maximum size of flat or corrugated reinforced plastics panel: 60″ x 130″; continuous maximum width—60″
Personnel: see p. 1178

Thompson Fiber Glass, H. I., Los Angeles

Types of molding done and kind of molds used: vacuum bag, autoclave, and press molding (from plaster tooling to matched metal dies)
Types of resin and reinforcement used: polyester, epoxy, phenolic and silicone resins; fibrous glass, asbestos, and refrasil reinforcement
Number and size of preformers: 1 with 4′ diameter turntable
Number of presses, platen area, and daylight space of each press: 10 presses ranging from platen sizes of 11″ to 16″ to 52″ to 88″; tonnage between 20 tons to 300 tons, and daylight between 3′ and 10′
Type of fabrication done: routing, shaping, drilling, turning
Pres.—H. I. Thompson
Exec. Vice Pres.—W. C. Winterhalter
Vice Pres., Sls. Mgr.—W. E. Bonke
Pur. Agt.—D. Welsh

Zenith Aircraft, Div. of Zenith Plastics Co., Gardena

Types of molding done and kinds of molds used: vacum bag, contact, vacuum impregnation, and matched die molding; molds of plaster, cast phenolic, aluminum, metal spray and hi-speed steel
Presses: 19—40 to 600 ton, up to 75″ x 104″ platen, up to 324″ daylight
Size of flat laminate sheet: 48″ x 150″
Types of resins and reinforcements used: phenolic, epoxy, silicone, and polyester resins with glass cloth, mat, roving and asbestos
Number and sizes of preformers: 6—up to 60″
Type of fabrication done: foam or honeycomb sandwich, glass preform, glass or asbestos reinforced; solid laminates

COLORADO

Chaney Plastic Molding Co., Denver

Types of molding done and kind of molds used: hand layup
Types of resin and reinforcement used: polyester resin; fibrous glass cloth and mat reinforcements
Personnel: see p. 1164

Sawaya Manufacturing Co., Inc., Trinidad

Type of molding done and kind of molds used: custom molding, all processes
Type of resin and reinforcement used: all types
Number and size of preformers: up to 20′ long
Maximum size of flat or corrugated reinforced plastics panel: 24 x 96 up to 60 x 96 inclusive
Personnel: see p. 1164

CONNECTICUT

Joclin Mfg. Co., Wallingford

Types of molding done and kinds of molds used: matched metal molding; hand layup
Types of resin and reinforcements used: epoxy, phenolic, silicone, fluorocarbon; glass, asbestos, etc.
Max. size of flat or corrugated reinforced plastics panel: 16″ x 16″
Type of fabrication done: all types
Personnel: see p. 1164

★New England Laminates Co. Inc., Stamford

Types of molding done and kind of molds used: matched metal molds
Types of resin and reinforcement used: epoxy resin—glass fabric
Number and size of preformers: 4
Personnel: see p. 1178

Rich Plastic Products, Meriden

Types of molding done and kind of molds used: compression and transfer; steel molds
Types of resin and reinforcement used: polyester resin; fibrous glass reinforcement
Personnel: see p. 1165

★U.S. Polymeric Chemicals, Inc., Stamford

Type of resins and reinforcements used: polyester, melamine, DAP, epoxy, silicone, phenolic
Type of fabrication: preimpregnating of glass fabrics, reinforcing mats and surfacing mats, etc.
Pres.—Marten Oudegeest
Vice Pres.—William S. Thornhill, E. J. Van Dyck

DELAWARE

Continental Can Co., Inc., Conolite Dept., Wilmington

Width and thickness of finished laminate: 36″ x 48″ wide; 0.005″ to 0.125″ thick
Personnel: see p. 1178

★Continental-Diamond Fibre Corp., Sub. of The Budd Co., Newark

Types of molding done and kind of molds used: matched metal molds
Types of resin and reinforcement used: polyester resin; fibrous glass preforms, mat, and cloth
Number and size of preformers: 1—30″ diameter
Number of presses, platen area, and daylight space of each press: 1—38″ x 72″ x 48″ daylight; 1—24″ x 30″ x 60″ daylight; 1—12″ x 18″ x 48″ daylight
Maximum size of flat or corrugated reinforced plastics panel: 36″ x 72″ flat sheet
Type of fabrication done: all types
Personnel: see p. 1165

National Vulcanized Fibre Co., Wilmington

Types of molding done and kind of molds used: compression molding with matched metal molds
Types of resin and reinforcement used: polyester resins; glass mat, roving and premix compounds
Number and size of preformers: 1 up to 40″ dia.
Number of presses, platen area, and daylight space of each press: 1—36 x 93″, 5″ daylight; 1—36 x 46, 3½″ daylight; 1—36 x 42, 1¾″ daylight
Type of fabrication done: complete fabrication service
Personnel: see p. 1179

FLORIDA

Fiber Glass Plastic, Inc., Miami

Types of molding done and kinds of molds used: vacuum bag molding; wood molds
Types of resin and reinforcements used: fibrous glass; polyesters and acrylics
Number of presses, platen area, and daylight space of each press: 1—small
Max. size of flat or corrugated reinforced plastics panel: 53″ x 144″
Continuous laminating: 54″ width continuous rolls, up to 100 ft. or more
Pres.—W. T. German
Sls. Mgr.—William E. Hudson
Pur. Agt.—Doris F. German

Lami-Plast Products Co., Tampa

Types of molding done and kinds of molds used: hand layup vacuum bag, and pressure molding with steel, wood, polyester, and epoxy molds
Types of resin and reinforcement used: epoxy, polyester, urea-formaldehyde resins; glass, synthetic, natural fibers
Max. size of flat or corrugated reinforced plastics panel: 4′ x 20′
Pres., Sls. Mgr., Pur. Agt.—Bernard N. Rothenberg
Vice Pres.—T. L. Hart

Plastex Laminates, Inc., Hialeah

Types of resin and reinforcement used: combinations of acrylic, epoxy, styrene, polyester, and silicone
Number of presses, platen area, and daylight space of each press: 1—special 20′ x 8′ x 1½ opening
Maximum size of flat or corrugated reinforced plastics panel: 20′ x 8′
Personnel: see p. 1165

Southern Plastic Products Co., Riviera Beach

Types of molding done and kind of molds used: hand layup, vacuum bag; plastics tooling (molds, jigs, dies)
Types of resin and reinforcement used: polyester and epoxy resin
Type of fabrication done: all finish operations, drilling, shaping, polishing, etc.
Pres., Pur. Agt.—Tom Nuttall, Jr.
Vice Pres.—V. A. Nuttall
Sls. Mgr.—John Childs

Valco, Inc., St. Petersburg

Types of molding done and kind of molds used: flat, decorative, and industrial corrugated and other shapes produced on metal dies
Types of resin and reinforcement used: light stabilized polyester and acrylic resins used in conjunction with fibrous glass printed fabrics and other reinforced and decorative materials

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Maximum size of flat or corrugated reinforced plastics panel: panel standard size up to 4′ x 12′. Special sizes on request
Pres.—Henry Valus
Vice Pres., Gen. Mgr.—Anver S. Suleiman

GEORGIA

Plastic Fabricants, Div. of The Woodman Co., Inc., Decatur

Types of molding done and kind of molds used: vacuum bag; wood, metal molds
Types of resin and reinforcement used: epoxy, polyester resins; fibrous glass reinforcement
Number of presses, platen area, and daylight space of each press: 1—24″ x 24″, 10″ daylight
Maximum size of flat or corrugated reinforced plastics panel: 24″ x 24″
Type of fabrication done: all types
Pres.—N. W. Heyward
Vice Pres.—A. H. Forsyth
Sales Mgr.—R. V. Young
Pur. Agt.—K. B. Davis

ILLINOIS

Bacon & Weber, Chicago

Type of molding done and kind of molds used: hand layup; low pressure and vacuum laminating
Types of resin and reinforcement used: epoxy, phenolic, polyester resins; fibrous glass, all fillers
Pres.—William Kings

★General American Transportation Corp., Plastics Div., Chicago

Types of molding done and kind of molds used: matched metal
Types of resin and reinforcement used: all types of resin and reinforcement
Number and size of preformers: 5
Size of presses: from 100 to 1000 tons
Personnel: see p. 1166

Hawley Products Co., St. Charles

Types of molding done and kinds of molds used: matched metal dies
Types of resin and reinforcement used: cellulose and glass fibers; thermoplastic and thermosetting resins
Number and size of preformers: 20—36″ x 36″
Number of presses, platen area, and daylight space of each press: 60 up to 36″ x 36″
Pres.—D. W. Hawley
Vice Pres.—A. P. Akerlund
Sls. Mgr.—Mano McLaughlin
Pur. Agt.—H. L. Breinig

High Strength Plastics Corp., Chicago

Types of molding done and kind of mold used: hand lay-up; plaster, wood, epoxy molds
Types of resin and reinforcement used: epoxy—glass cloth and mat; polyester—glass cloth and mat
Pres., Sls. Mgr.—Charles E. Chastain
Vice Pres.—Henry B. Sartorius
Pur. Agt.—James Powers

Molex Products Co., Brookfield

Types of molding done and kind of molds used: matched metal molds
Types of resin and reinforcement used: polyester, epoxy, phenolic
Number of presses, platen area, and daylight space of each press: 50 ton to 250 ton; 24″ x 24″ to 24″ x 40″
Pres., Sls. Mgr.—J. H. Krehbiel
Vice Pres.—E. P. Krehbiel
Pur. Agt.—Art. Schroeder

Schramm Fiberglass Products, Inc., Chicago

Types of molding done and kind of molds used: hand layup, plug, vacuum bag
Types of resin and reinforcement used: epoxy, polyester, polyurethane
Pres., Sls. Mgr.—R. W. Voigt
Pur. Agt.—R. Heim

Terox Corp. of America, Franklin Park

Type of molding done: compression, matched-metal die
Type of resin and reinforcement: polyester and fibrous glass
Number of presses: 3—50 ton, 30″ x 40″
Specialize in simulated stone panels

INDIANA

Calumet Fiberglass Products Co., Hammond

Types of molding done and kind of molds used: contact, vacuum bag, pressure, and matched metal moldings; wood, plaster, and steel molds
Types of resin and reinforcement used: polyester, epoxy, and phenolic resins
Number of presses, platen area, and daylight space of each press: 2: 1—14″ x 20″ platen area, 12″ daylight; 1—36″ x 60″ platen area, 12″ daylight
Maximum size of flat or corrugated reinforced plastics panel: 32″ x 60″ and 36″ x 56″
Personnel: see p. 1167

General Tire & Rubber Co., The, Marion

Types of molding done and kind of molds used: vacuum bag with wood, plastic, and steel molds; plastic and matched metal molding; rubber bag and metal combination molding
Types of resin and reinforcement used: glass cloth, mat, and preform; also sisal. Polyester, phenolic, epoxy, and silicone resins
Number and size of preformers: 5 preforms up to 48″, 1—30″ rotary
Number of presses, platen area, and daylight space of each press: 40 presses, platen area ranging from 14″ x 32″ to 72″ x 84″; daylight opening ranging from 6″ to 96″
Maximum size of flat or corrugated reinforced plastics panel: flat sheet—48″ x 96″; corrugated sheet—48″ x 96″
Type of fabrication done: routing, drilling, sanding, painting, assembly of metal to plastics, inserts molded in part
Pres.—W. O'Neil
Vice Pres.—O. G. Vinnedge
Sls. Mgr.—Fred W. Dover
Pur. Agt.—V. A. Cornell

★Polygon Plastic Co., Walkerton

Types of resin and reinforcement used: resin—polyester and epoxy; reinforcement—fibrous glass
Type of machine: continuous fully automatic extrusion-type equipment
Specialize in: seamless glass-reinforced epoxy and polyester tubing
Pres.—S. M. Shobert
Vice Pres.—G. S. Parks
Sls. Mgr.—E. R. Jaques

Pribble Plastics Products, Inc., New Haven

Types of molding done and kind of molds used: hand layup, vacuum bag, and matched metal molding in aluminum or steel molds
Types of resin and reinforcement used: polyester resin; fibrous glass or sisal
Number of presses, platen area, and daylight space of each press: 2—18 x 20, 28 in. daylight; 2—13 x 18, 28 in. daylight; 1—30 x 36, 40 in. daylight
Personnel: see p. 1167

Rostone Corp., Lafayette

Types of molding done and kind of molds used: compression and transfer
Types of resin and reinforcement used: polyester resin; fibrous glass reinforcement
Number of presses, platen area, and daylight space of each press: 41—5 ton to 1500 ton compression presses; 2—30 ton to 75 ton transfer presses
Personnel: see p. 1167

KANSAS

Lamicell Engineering, Baxter Springs

Types of molding done and kind of molds used: matched metal, bag, and hand layup
Types of resin and reinforcement used: polyester, epoxy, and epoxy-polyamide resins; glass, Dynel and nylon reinforcements
Number and size of preformers: 1—18″ x 80″ double automatic
Number of presses, platen area, and daylight space of each press: 3—24″ platen x 24″ stroke, 35″ daylight; 1—40″ x 44″ x 61″ daylight, 150 ton; 2—36″ x 86″ x 60″ daylight, 150 ton
Type of fabrication done: routing, drilling, secondary bonding
Pres.—Bob Blake
Sls. Mgr., Vice Pres.—E. Blanset
Pur. Agt.—D. W. Dickerson

Plastic Fabricating Co., Inc., Wichita

Types of molding done and kind of molds used: glass cloth, mat, premix and preform in matched metal molds, vacuum bag, open mold, pressure bag, and spray-up systems
Types of resin and reinforcement used: polyester, epoxy and silicone resins; fibrous glass, sisal, and asbestos reinforcements
Number and size of preformers: 1—48″
Number of presses, platen area, and daylight space of each press: 1—50 x 60, 60″ daylight; 1—40 x 50, 36″ daylight; 1—20 x 30, 18″ daylight
Type of fabrication done: custom
Pres., Sls. Mgr.—Felix M. Farrell
Vice Pres., Sls. Mgr.—Joe H. Yeager
Pur. Agt.—John W. Hickman

MAINE

Maine Molding Products, Boothbay Harbor

Types of molding done and kind of molds used: matched metal molds, wooden molds, reinforced polyester molds, and epoxy molds
Types of resin and reinforcement used: polyester, epoxy, phenolic, melamine, styrene
Number of presses, platen area, and daylight space of each press: 1—10′ x 11′ platen, 800 ton; 3—22″ x 24″ platen, 75 ton
Max. size of flat or corrugated reinforced plastics panel: any size up to 10′ x 10′
Specialize in: large marine structural components, floats, and caskets
Personnel: see p. 1167

Monmouth Fiberglass Industries, Monmouth

Types of molding done and kind of molds used: hand layup on wood molds; press molding in matched metal molds
Types of resin and reinforcement used: polyesters and epoxies
Number of presses, platen area, and daylight space of each press: 1—30″ x 48″ platen, 26″ stroke; 1—22″ x 38″ platen, 30″ stroke
Maximum size of flat or corrugated reinforced plastics panel: flat panels to 84″ x 120″
Type of fabrication done: complete fabricating facilities including mold shop

MARYLAND

Artmor Plastics Corp., Cumberland

Type of molding done and kind of molds used: matched metal molding
Types of resin and reinforcement used: polyester resin and acrylic syrups; fibrous glass, sisal, synthetic, and natural fibers
Number of presses, platen area, and daylight space of each press: 1—250 ton, 36″ x 36″, 20″ daylight; 3—air cylinder presses, 24″ x 30″, 20″ daylight

Englander Co., Inc., The, Industrial Plastics Div., Baltimore

Types of molding done and kind of molds used: vacuum bag, pressure; wood, reinforced plastic, and metal molds
Types of resin and reinforcement used: polyester and epoxy resins
Number of presses, platen area, and daylight space of each press: 10—up to 5′ x 8′; up to 30″ daylight
Max. size of flat or corrugated reinforced plastics panel: 5′ x 8′
Personnel: see p. 1179

MASSACHUSETTS

Atkins & Merrill, Inc., Reinforced Plastics Div., Marlboro

Types of molding done and kind of molds used: hand laminating with plaster, plastics, and wood molds; vacuum bag molding
Types of resin and reinforcement used: epoxy and polyester resins; fibrous glass reinforcement (roving, mat, cloth)
Number of presses, platen area, and daylight space of each press: 1 press, 36″ x 36″, max. 40″ daylight
Pres.—Roger Merrill
Vice Pres.—N. C. Wiley
Sls. Mgr.—A. V. Boyce
Pur. Agt.—R. Johnson

Beetle, Carl N., Plastics Corp., Fall River

Types of molding done and kind of molds used: hand layup, vacuum bag, and matched metal molding; wood, plaster, cast epoxy, and metal molds
Types of resin and reinforcement used: polyester and epoxy resin; glass, asbestos, Orlon, Dynel, and sisal fiber reinforcement; wood flour filler; polyurethane foam cores
Number of presses, platen area, and daylight space of each press: 12 presses, varying from 12″ x 12″ to 38″ x 38″; average 36″ daylight; also 1—6′ x 6′ and 1—6′ x 12′
Maximum size of flat or corrugated reinforced plastics panel: flat panel, 6′ x 10′
Type of fabrication done: all machine shop operations
Specialize in: tanks, stacks, ducting, radomes, chemical transporters, vents, hoods, housings, dye trucks, electronic components, aircraft

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Pres.—Frederick W. Howe Jr.
Vice Pres. and Gen. Mgr.—Richard C. Bryan
Sales Mgr.—William M. Milne
Pur. Agt. and Management Ass't.—Howard C. Conlon

★Blank & Co., Inc., Arthur, Boston

Number of presses, platen area, and daylight space of each press: 3 presses, 1—12 x 12, 10 openings; 1—18 x 21, 4 openings; 1—24 x 54, 9 openings
Type of fabrication done: die cutting, folding, punching, forming, printing, finishing
Personnel: see p. 1179

Clark-Cutler & McDermott, Franklin

Types of molding done and kind of molds used: aluminum pattern plates; compression molding
Types of resin and reinforcement used: vinyl resin; sisal, wool, and cork
Number of presses, platen area, and daylight space of each press: 1—40 x 60, 10 opening, 2½" daylight; 5—40 x 40, 10 openings, 2½" daylight
Personnel: see p. 1168

Douglas Manufacturing Corp., Peabody

Types of molding done and kinds of molds used: hand layup in wooden molds; press molding in matched metal molds
Types of resin and reinforcements used: polyester and epoxy resins
Number of presses, platen area, and daylight space of each press: 1—20" x 24" platen area x 12" stroke
Type of fabrication done: complete fabricating facilities including mold shop

Lawrence Adhesive & Chemical Co., Inc., Lawrence

Types of molding done and kind of molds used: various; wood, metal, and plastic
Types of resin and reinforcement used: epoxy; glass or steel wool; silica, etc.
Number of presses: 1
Personnel: see p. 1168

Marscot Plastics, Inc., Fall River

Types of molding done and kind of molds used: contact molding; vacuum injection (Marco)
Types of resin and reinforcement used: fibrous glass cloth, mat, and roving

Plastic Industrial Products, Div. of Carlon Products Corp., Somerville

Does continuous laminating
Width and thickness of finished laminate: 1" width extrusions

Wasco Products, Inc., Cambridge

Types of resin and reinforcement used: acrylic resin; fibrous glass reinforcement
Maximum size of flat or corrugated reinforced plastics panel: flat or corrugated 48", unlimited length
Width and thickness of finished laminate: 72" wide x 0.010" to 0.250"
Pres.—Max Wasserman
Sls. Mgr.—W. D. O'Morrow
Pur. Agt.—S. M. Friedberg

MICHIGAN

Ameriplastic Co., The, Flint

Type of molding done and kind of molds used: spray-up molding; wood and plaster molds
Types of resin and reinforcement used: epoxy and polyester resins
Pres.—Joel S. Graves
Vice Pres.—Joel G. Graves

★Brunswick-Balke-Collender Co., Defense Products Div., Muskegon

Types of molding done and kind of molds used: vacuum bag, pressure bag, filament winding; steel, plastic, and sprayed metal molds
Types of resin and reinforcements used: polyester, epoxy, phenolic, silicone, etc.; fibrous glass cloth, roving and mat reinforcements
Number and size of preformers: 2—30"
Number of presses, platen area, and daylight space of each press: 5—30" x 40" to 50" x 80"; 6—20" x 30"
Vice. Pres. and Gen. Mgr.—K. A. Day
Sales Mgr.—L. A. Niedfeldt
Pur. Agt.—R. Deal

Duralastic Products Company, Detroit

Types of molding done and kinds of molds used: compression molding; matched metal dies
Types of resin and reinforcements used: polyester resin; fibrous glass and sisal reinforcements
Number and size of preformers: 1—42"
Number of presses, platen area, and daylight space of each press: 27, with beds 14" x 16" up to 48" x 72"
Max. size of flat or corrugated reinforced plastics panel: 4' x 6'
Personnel: see p. 1168

★Fabricon Products, Inc., River Rouge

Types of molding done and kind of molds used: compression molding, reinforced plastics
Types of resin and reinforcement used: polyester resins; fibrous glass and sisal reinforcements, mat and premix compounds
Number and size of preformers: 1—48" x 48"
Number of presses, platen area, and daylight space of each press: Up to 42" x 60", maximum daylight, 65"
Personnel: see p. 1168

General Machine & Tool Works, Walled Lake

Types of molding done and kind of molds used: wood and metal molds, vacuum bag
Types of resin and reinforcement used: epoxy, polyester
Number of presses, platen area, and daylight space of each press: 1—24" x 20" x 18", 1—14" x 14" x 11"
Maximum size of flat or corrugated reinforced plastics panel: 22" x 18"
Type of fabrication done: routing, shaping, drilling, cementing

Grand Haven Plastic Co., Grand Haven

Types of molding done and kind of molds used: compression, steel molds
Types of resin and reinforcement used: polyester; fibrous glass
Number of presses, platen area, and daylight space of each press: 2—20" x 30", 20" daylight; 2—36" x 48", 30" and 48" daylight; 2—48" x 72", 60" daylight

Harstil Industries Co., St. Clair Shores

Types of molding done and kind of molds used: contact and matched metal molding; rolled round and square tubing
Types of resin and reinforcement used: epoxy and polyester resin; glass cloth, mat, or roving
Type of fabrication done: routing, shaping, drilling, turning, grinding, etc.
Pres.—H. H. Stilson, Jr.
Vice Pres.—A. A. Stilson

MacDonald Mfg. Co., New Baltimore

Types of molding done and kind of molds used: polyester; premix
Types of resin and reinforcement used: polyester resins; sisal, fibrous glass, etc.
Number of presses, platen area, and daylight space of each press: 2—48" x 48"
Personnel: see p. 1169

Reynolds Plastics, Inc., Walled Lake

Types of molding done and kind of molds used: low-pressure, hand layup, bag, and premix molding; wood, metal, and plastic molds
Types of resin and reinforcement used: polyester, epoxy, and phenolic resins; fibrous glass and sisal reinforcement
Number of presses, platen area, and daylight space of each press: 1—12" x 18" x 11" opening; 1—26" x 24" x 18" opening
Maximum size of flat or corrugated reinforced plastics panel: 24" x 22" flat panels
Type of fabrication done: cutting, routing, cementing, drilling, shaping, tapping, etc.
Personnel: see p. 1169

Woodall Industries, Inc., Detroit

Types of molding done and kind of molds used: premix fiber reinforced; steel matched molds
Types of resin and reinforcement used: polyester resins; sisal, glass and synthetic fibers
Number of presses, platen area, and daylight space of each press: 28—up to 1000 tons; platen areas up to 48" x 72", daylight up to 54"
Does continuous laminating
Width and thickness of finished laminate: 48" x 192"
Type of fabrication done: complete fabricating facilities
Personnel: see p. 1169

MINNESOTA

Valco Corp., St. Paul

Types of molding done and kind of molds used: compression, vacuum bag, and hand layup (contact)
Types of resin and reinforcement used: polyester, phenolic, epoxy, silicone, alkyd, and melamine resins; glass, cotton, asbestos, and sisal reinforcements
Number and size of preformers: 1—36"
Number of presses, platen area, and daylight space of each press: 1—36" x 36", 200 ton, 48" daylight; 2—36" x 36", 150 ton, 36" daylight; 1—24" x 72", 250 ton, frame press
Type of fabrication done: all types of reinforced plastic including fibrous glass filament winding
Pres.—Willard M. Bollenbach
Vice Pres., Sls. Mgr.—William J. Houlihan

MISSOURI

Hanley Plastics Co., St. Louis

Types of molding done and kind of molds used: all types
Types of resin and reinforcement used: epoxy and polyester resin
Type of fabrication done: all
Pres.—A. J. Spanogle

Regal Plastic Co., Kansas City

Types of molding done and kind of molds used: high-pressure matched metal die molding
Types of resin and reinforcement used: Polyester resins; fibrous glass reinforcement
Number and size of preformers: 52"
Number of presses, platen area, and daylight space of each press: 1—40" x 50", platen area; 1—50" stroke, 70" daylight
Type of fabrication done: complete finishing and assembly
Pres., Sls. Mgr.—J. S. Kivett
Pur. Agt.—Walter Cooper

NEBRASKA

Kerrco Products, Lincoln

Types of molding done and kind of molds used: matched metal molding and open layup
Types of resin and reinforcement used: polyesters and epoxy; glass and sisal fibers
Number of presses, platen area, and daylight space of each press: 3 up to 35" x 46" 26" daylight
Type of fabrication done: all types
Personnel: see p. 1170

Omaha Plastics Co., Omaha

Types of molding done and kind of molds used: casting with aluminum molds
Types of resin and reinforcement used: epoxy, fibrous glass cloths, mats & Dacron
Personnel: see p. 1170

NEW JERSEY

American Molded Fiberglass, Paterson

Types of molding done and kind of molds used: hand layup, vacuum and matched metal molding
Types of resin and reinforcement used: polyester and epoxy resin, glass, paper, and other fiber reinforcements
Number of presses, platen area, and daylight space of each press: 5 presses (3 air, 2 hydraulic); 1—2' x 2', 2' daylight; 2—1' x 6', 2½' daylight; 1—2½' x 2¼' (hyd.) with 3' daylight; 1—3' x 4½' (hyd.), 4' daylight
Specialize in: swimming pools, plating tanks, and other large items; paper pulp moldings
Pres., Pur. Agt.—S. Quontzel
Vice Pres.—H. Quontzel
Sls. Mgr.—J. Berk

Firmaline Products, Inc., Midland Park

Types of molding done and kind of molds used: contact, vacuum bag, matched metal, premix and compression; cast plastic tooling
Types of resin and reinforcement used: polyester and epoxy resins; fibrous glass, sisal and synthetic fiber reinforcements
Number of presses, platen area, and daylight space of each press: 4: 1—50" x 72", 9' daylight; 1-24" x 36", 3' daylight; 1—12" x 18", 30"; 1-12" x 18", 26"
Type of fabrication done: post molding fabrication, routing, drilling, stamping, machine finishing, etc.
Pres.—E. R. Gelles
Vice Pres. & Gen. Mgr.—Robert W. Lade
Sls. Mgr.—James C. Doyle
Pur. Agt.—M. Nekervis

Modular Molding Corp., Burlington

Types of molding done and kind of molds used: contact layup, vacuum bag, matched die molding; plastic, wood, aluminum and steel molds
Types of resin and reinforcement used: polyester, epoxy, and urethane; fibrous glass mat and cloth, asbestos, sisal, and premix compounds

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Number of presses, platen area, and daylight space of each press: 1—18" x 18", 48", 100 ton; 1—6" x 6", 18", 100 ton; 1 continuous rotary press 50" width, 14" daylight space, 12' long
Maximum size of flat or corrugated reinforced plastics panel: 48" x 144" flat; 42" x 144" corrugated
Width and thickness of finished laminate: up to 48" width, up to ¼" thick, plus various core materials up to 12" thick
Type of fabrication done: structural modular sandwich panels for architectural, transportation, and radome applications
Personnel: see p. 1171

Pitman Plastic Products, Inc., Pitman

Types of molding done and kind of molds used: sprayed metal, plastic, and wooden molds
Types of resin and reinforcements used: epoxy and polyester resins; expanded plastics cores
Pres. & Pur. Agt.—Emerich E. Lesch
Vice Pres.—Violet M. Lesch

Plastic Laminating Corp., Vauxhall

Number of presses, platen area, and daylight space of each press: 2—24 x 26; 1—24 x 54; 1—36 x 48 (8 openings; 2" daylight)
Personel: see p. 1171

Winner Mfg. Co., Inc., Trenton

Types of molding done and kinds of molds used: matched die, positive pressure bag, vacuum bag, hand layup, on all types molds
Number of presses, platen area and daylight space of each press: 11 presses, 60" x 66" to 12" x 12"; daylight, 77⅞" to 80"
Size of flat laminate sheet made: 25⅜" x 36"; 36½" x 36½"; 33½" x 36½"; 33⅝" x 39⅞"
Type of resins and reinforcements used: glass, vegetable fibers, mineral fibers, polyester, epoxy
Number and sizes of preformers: one 48"
Type of fabrication: assembly, bonding, piercing, drilling, machining
Pres.—I. M. Scott
Vice Pres., Sls. Mgr.—H. L. Darby
Pur. Agt.—D. A. White

Young Development Div., Explosives Dept., Hercules Powder Co., Rocky Hill

Types of molding done and kind of molds used: filament winding
Types of resin and reinforcement used: epoxy resin; fibrous glass reinforcement
Personnel: see p. 1172

NEW YORK

American Plastics Corp., New York

Types of molding done and kind of molds used: preform and premixed molding by matched metal steel molds
Types of resin and reinforcement used: polyester resin; glass, sisal, and asbestos fiber
Number and size of preformers: 3
Number of presses, platen area, and daylight space of each press: 10—max. 40" x 76", max. daylight 84"

Aries Laboratories, Inc., Long Island City

Types of molding done and kind of molds used: vacuum casting, aluminum or steel molds
Types of resin and reinforcements used: epoxy
Personnel: see p. 1172

Atlas Plastics, Inc., Buffalo

Types of molding done and kind of molds used: Vacuum bag, contact, matched die, breakaway cores
Types of resin and reinforcement used: Polyester, epoxy, and phenolic resins; fibrous glass roving, fibers, mat and fabric
Number of presses, platen area, and daylight space of each press: 5—up to 100 ton, up to 36" x 48" platen area, up to 30" daylight
Maximum size of flat or corrugated reinforced plastics panel: 36" x 48"
Type of fabrication done: routing, shaping, drilling

Bo-Mer Mfg. Co., Inc., Auburn

Types of molding done and kind of molds used: steel molds, compression
Types of resin and reinforcement used: polyester resin; glass fabric and mat
Number and size of preformers: hand only
Number of presses, platen area, and daylight space of each press: 1—50 ton 18" x 18" x 7"; 3—30 ton, 10" x 10" x 6"
Personnel: see p. 1172

Du Verre, Inc., Arcade

Types of molding done and kinds of molds used: contact and vacuum bag molding on wood, metal, and plaster molds
Types of resin and reinforcements used: polyester, epoxy, and furfuryl alcohol resins; fibrous glass reinforcements
Type of fabrication done: assembly of tubes; drilling and facing of flanges
Pres.—J. R. Kelly
Sls. Mgr.—T. F. Killeen
Pur. Agt.—Henry Hasbrouck

Fairchild Guided Missiles Div., Fairchild Engine & Airplane Corp., Wyandanch

Types of molding done: vacuum bag, autoclave, matched die, mandrel winding, and premix
Presses: 7 presses—maximum size 84" x 48" x 56" daylight, 250 tons with heated platens
Size of flat laminate sheet: up to 48" x 84"
Type of resins and reinforcements used: polyester, epoxy, and phenolic resins with glass fabrics, mats rovings, and chopped fibers
Type of fabrication: missile and aircraft structural components, containers, and pressure vessels
Gen. Mgr.—E. A. Speakman
Pur. Agt.—G. J. Ryan
Mgr. Plastics—C. R. Lemonier

Glasply Corp., Mount Vernon

Types of molding done and kind of molds used: vacuum bag, hand layup, and press molding; (low pressure) tubing; wood, aluminum, plaster and steel molds
Types of resin and reinforcement used: polyester, epoxy, silicone, phenolic resins; fibrous glass fabric, mat, roving, premix, prepreg
Number of presses, platen area, and daylight space of each press: 1—18" x 18", 24" daylight
Type of fabrication done: Routing, drilling, grinding, close tolerance machining
Specialize in: tubing, radomes, instrument cases, antenna masts
Pres.-Sales Mgr.—Frank A. Lambert
Sec.-Treas.—Ralph Dell'Abate
Pur. Agt.—Spirov David

Jay Moulding Corp., Cohoes

Types of molding done and kinds of molds used: compression molding; steel molds
Types of resin and reinforcements used: polyester resins; fibrous glass, sisal and asbestos; premix molding compounds
Number of presses, platen area, and daylight space of each press: 1—20" x 21", daylight 20"; 1—22" x 22½", daylight 22"; 1—24" x 30", daylight 60"

Lunn Laminates, Inc., Huntington Station

Types of molding done and kind of molds used: contact, vacuum bag, and press molding; mandrel wrapping; polyester, epoxy, steel and aluminum molds
Types of resin and reinforcement used: polyester and epoxy resins; fibrous glass, cotton, and synthetic fiber reinforcements
Number and size of preformers: 1—36"
Number of presses, platen area, and daylight space of each press: 1—44" x 21", 66"; 1—36" x 24", 48"; 1—24" x 20", 46"; 1—43" x 28", 29"; 1—49" x 55", 80"; 1—42" x 36", 62"
Type of fabrication done: all types
Pres.—James S. Lunn
Exec. Vice Pres.—Harry T. Douglas
Sls. Mgr.—James W. Sedore
Pur. Agt.—Edward W. Kirchner

Norton Laboratories, Inc., Subsidiary of Auburn Plastics, Inc., Lockport

Types of molding done and kind of molds used: compression; hardened steel molds
Types of resin and reinforcement used: chopped fibrous glass; polyester premixed dry blends
Personnel: see p. 1173

Plasti-Skill Co., Corona

Types of molding done and kind of molds used: hand layup
Types of resin and reinforcement used: polyester and epoxy resins
Number of presses, platen area, and daylight space of each press: 1—20" x 60", 30" daylight
Pres., Sls. Mgr., Pur. Agt.—Nick George

Riverside Plastics Corp., Hicksville

Types of molding done and kind of molds used: press, vacuum bag, and diffusion molding; metal, wood, and plastic molds
Types of resin and reinforcement used: polyesters, phenolics, epoxies, silicones with fibrous glass roving, mat, Orlon, Dacron, and cotton duck
Number and size of preformers: 1—6' x 2'
Number of presses, platen area, and daylight space of each press: 30; maximum platen area, 40" x 60"; maximum daylight, 8'
Type of fabrication done: cutting, shaping, drilling, milling, grinding, trimming, etc.

Russell Reinforced Plastics Corp., Lindenhurst

Types of molding done and kinds of molds used: airfoil and varying shapes in continuous woven reinforcement and molding compound, matched metal dies, vacuum bag and contact laminating
Number of presses, platen area and daylight space of each press: 42 presses ranging in size up to 4' x 9' platen area, pressure up to 1,000 ton, stroke to 48", daylight to 120"
Size of flat laminate sheet made: up to 4' x 10'
Type of resins and reinforcements used: polyester, epoxy, silicone, and phenolic resins, glass and synthetic fiber cloth and mat reinforcements
Type of fabrication: matching, bonding, riveting, and assembly of parts and hardware to produce finished products, e.g., doors, radomes, fairings, containers
Pres.—Alfred W. Russell
Exec. Vice Pres., Treas., Sls. Mgr.—Ernest C. Schultz
Pur. Agt.—Fred C. Turner

Scheidl Mfg. Co., Copiague

Types of molding done and kind of molds used: vacuum bag and matched metal molding, all types of molds
Types of resin and reinforcement used: epoxy, polyester, silicones, DAP, phenolic; all types of reinforcements
Number of presses, platen area, and daylight space of each press: 20—from 12" x 12" to 30" x 36" platen; 12" to 30" daylight
Type of fabrication done: all types of fabricating
Pres.—John Scheidl
Vice Pres.—James Reidy
Sls. Mgr.—H. E. Fowler
Pur. Agt.—M. Concannon

Schori Process Corp., Long Island City

Types of molding done and kind of molds used: contact and hand layup on wood, plaster, metal and reinforced plastic molds
Types of resin and reinforcement used: polyester and epoxy resins; fibrous glass, cotton, Dynel and other reinforcements
Maximum size of flat or corrugated reinforced plastics panel: 50" x 152", up to ½" thick
Type of fabrication done: make equipment for chemical processing, tanks, ducts, exhaust systems, crocks, hoods, etc.
Pres., Sls. Mgr.—Bernard Goldberg
Vice Pres.—K. Carroad
Pur. Agt., Treas., Plant Mgr.—Morton J. Gurdin

Silicone Insulation, Inc., Bronx

Types of molding done and kind of molds used: matched metal, vacuum bag, wet layup, autoclave molding
Types of resin and reinforcement used: polyester, silicone, epoxy, phenolic, melamine
Number of presses, platen area, and daylight space of each press: 12—up to 48"
Type of fabrication done: all machining
Personnel: see p. 1173

Teitelbaum Sons, N., Inc., New York

Number of presses, platen area, and daylight space of each press: 1—51½ x 73 platen area —14" daylight space, 1—54 x 120 platen area —14" daylight space
Personnel: see p. 1180

Virginia Plak Co., New York

Number of presses, platen area, and daylight space of each press: 2—20 x 24, 10 openings; 1—25 x 38, 10 openings; 1—30 x 40, 10 openings; 1—31 x 38, 10 openings
Type of fabrication done: cutting, die cutting, punching, drilling, sanding, routing, polishing and buffing

Lawrence Wittman & Co., Massapequa

Types of molding done and kind of molds used: matched and vacuum bag molding; plastic, steel, aluminum, plaster, wood, and hand layups
Types of resin and reinforcement used: polyester and epoxy resins; fibrous glass cloth, mat, premix, and prepreg reinforcements
Number of presses, platen area, and daylight space of each press: 10 presses: 10—up to 24 x 38; daylight to 4'
Type of fabrication: routing, sawing, drilling, sand blast, bonding, and assembly
Pres.—Lawrence Wittman

OHIO

Apex Reinforced Plastics Div., White Sewing Machine Corp., Cleveland

Types of molding done and kind of molds used: matched metal molding; centrifugal mold process; filament winding

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Types of resins and reinforcement used: polyester and epoxy resins; glass reinforcement
Number and size of preformers: 2—36″ Brenner and 5—28″ Turner preformers (all with ovens)
Number of presses, platen area, and daylight space of each press: 6—36″ x 42″ platen w/80″ daylight; 1—36″ x 36″ platen w/40″ daylight; 1—42″ x 42″ platen w/80″ daylight
Personnel: see p. 1180

Armored Plastics Co., Div. of Globe-Wernicke Industries, Inc., Toledo

Types of molding done and kind of molds used: fibrous glass mat and fibrous glass preformed parts in matched metal molds
Types of resin and reinforcement used: polyester resins and glass fibers
Number and size of preformers: 1—28″; 1—36″; 2—48″
Number of presses, platen area, and daylight space of each press: 1—48″ x 36″ bed, 4′ stroke, 84″ daylight; 2—60″ x 42″ bed, 4′ stroke, 84″ daylight; 1—60″ x 84″ bed, 4′ stroke, 84″ daylight
Type of fabrication done: molding, blanking, piercing, bonding, drilling, and assembling
Pres.—William D. Hahn
Vice Pres.—Joseph F. Howard
Sls. Mgr., Plastics Div.—Robert S. Beverlin
Pur. Agt.—W. J. Todd
Secy.—W. H. Patterson
Chief Engineer—W. F. Krueger

Cincinnati Development & Mfg. Co., Cincinnati

Types of molding done and kind of molds used: hydraulic pressure; matched metal molds
Types of resin and reinforcement used: polyester resin; fibrous glass reinforcement
Number of presses, platen area, and daylight space of each press: 1—30 ton; 1—50 ton; 1—60 ton
Maximum size of flat or corrugated reinforced plastics panel: 24″ x 38″
Type of fabrication done: stamping, shearing, drilling, milling, sawing, routing, and shaping
Pres.—W. H. Mooney
Vice Pres., Sls. Mgr.—W. M. Mooney
Pur. Agt.—E. D. Mooney

The Cincinnati Milling Machine Co., Cimastra Div., Cincinnati

Types of molding done and kind of molds used: matched metal molding and steel molds
Types of resin and reinforcement used: polyester resin; fibrous glass reinforcement
Type of fabrication done: drilling and punching

Columbus Moulded Products Corp., Columbus

Types of molding done and kind of molds used: matched metal
Types of resin and reinforcement used: epoxy and polyester resins; fibrous glass reinforcement

Francis Industries, Pataskala

Types of molding done and kinds of molds used: compression, premix, wet layup; extrusion of reinforced rods and tubes
Types of resin and reinforcements used: epoxy, polyester, and alkyd resins; fibrous glass roving
Number of presses, platen area, and daylight space of each press: 6 presses to 50 tons, special design
Types of fabrication done: all types on rods and tubes
Specialize in: high strength electrical and chemical tubing of fibrous glass, roving and polyester and epoxy resins
Personnel: see p. 1174

General Electric Co., Laminated Products Dept., Coshocton

Types of molding done and kind of molds used: matched metal molding
Types of resin and reinforcement used: polyester resin with fibrous glass and discontinuous fillers
Maximum size of flat or corrugated reinforced plastics panel: 36½″ x 36½″
Type of fabricating done: cutting to size by sawing or shearing
Personnel: see p. 1180

★General Industries Co., The, Elyria

Types of molding done and kind of molds used: compression and plunger transfer molding
Types of resin and reinforcement used: polyester-reinforced premix; also compounds own premix material
Number of presses, platen area, and daylight space of each press: 112—from 11″ x 24″ to 48″ x 87″; from 13″ to 90″ daylight
Personnel: see p. 1174

Goodyear Aircraft Corp., Akron

Types of molding done and kinds of molds used: vacuum bag, matched dies, autoclave using plastic, plaster, wood and metal dies
Number of presses, platen area and daylight space of each press: 18 presses up to 179″ x 95″, platen up to 144″ daylight
Size of flat laminate sheet made: 38″ x 96″
Type of resins and reinforcements used: polyester, epoxy, phenolic, silicone, glass and synthetic fibers, mats, rovings, preforms
Number and sizes of preformers: 1—28″, 1—72″, 1—120″
Type of fabrication done: foam and honeycomb sandwich, void-free laminates, custom design and proprietary commercial laminates
Pres.—T. A. Knowles
Vice Pres.—R. W. Richardson
Sls. Mgr.—M. B. Jobe
Pur. Agt.—H. A. Delaney

Heil Process Equipment Corp., Cleveland

Types of molding done and kind of molds used: hand-layup
Types of resin and reinforcement used: polyesters and epoxies; fibrous glass
Pres.—C. E. Heil
Vice Pres. & Sls. Mgr.—E. W. Vereeke
Pur. Agt.—M. P. Heil

Mold-Rite Plastics, Inc., Cambridge

Types of molding done and kind of molds used: matched metal molds
Types of resin and reinforcement used: polyester resin; sisal and fibrous glass

Molded Fiber Glass Co., Ashtabula

Types of molding done and kind of molds used: matched metal molding
Types of resin and reinforcement used: polyester resin; fibrous glass reinforcement
Number and size of preformers: 2—52″ dia. tables; 2—36″ dia. tables; 2—30″ dia. tables; 2—48″ dia. tables
Number of presses, platen area, and daylight space of each press: 1—61″ x 50″ x 80″; 2-54″ x 50″ x 80″; 3—42″ x 48″ x 30″; 5—32″ x 36″ x 42″; 7—30″ x 30″ x 60″; 2—24″ x 30″ x 30″; 1—20″ x 20″ x 30″
Specialize in: all fields except transportation and materials handling
Pres.—R. S. Morrison
Vice Pres., Gen. Mgr.—Chester Ward
Sls. Mgr.—Wallace Feasler
Pur. Agt.—Kenneth Sippola

Molded Fiber Glass Body Co., Ashtabula

Types of molding done and kind of molds used: matched metal molding
Types of resin and reinforcement used: polyester resin; fibrous glass reinforcement
Number and size of preformers: 1—120″ dia. table; 1—150″ dia. table; 2—100″ dia table; 3—52″ dia. table; 3-36″ dia. table; 1-26″ dia. table
Number of presses, platen area, and daylight space of each press: 1—34″ x 144″ x 80″; 2—96″ x 96″ x 80″; 1—60″ x 100″ x 80″; 3—61″ x 50″ x 80″; 10—54″ x 50″ x 80″; 6—42″ x 48″ x 80″; 5—24″ x 30″ x 30″; 8—20″ x 30″ x 30″; 1—96″ x 120″ x 120
Specialize in: transportation industry
Pres.—R. S. Morrison
Vice Pres., Mfg.—R. L. Wiese
Vice Pres., Eng.—Morgan Martin
Sales Mgr.—L. L. Palmer
Prod. Mgr.—D. C. Searl

Molded Fiber Glass Sheet Co., Ashtabula

Types of molding done and kind of molds used: matched metal molding
Type of fabrication: honeycomb panels made with RP surfacings and punched parts from RP sheet
Number of presses, platen area, and daylight space of each press: 1—60″ x 100″ x 42″; 2—40″ x 76″ x 42″; 1—42″ x 48″ x 42″
Size of flat laminate sheet: max. size 56″ x 96″
Pres.—Herbert Gordon
Vice Pres.—R. S. Morrison
Sls. Mgr.—Robert Gilbert
Prod. Mgr.—Charles Parks

Plastic Products Corp., Bedford Heights

Types of molding done: matched metal die molding
Types of resin and reinforcement used: polyester and fibrous glass
Number and size of preformers: 3—36″ and 38″ Brenner Shuttle; 54″ Open Type Erie.
Number of presses, platen area of each: 7—25 to 200 tons; platens from 25″ x 25″ to 50″ x 50″
Pres.—S. B. Knight
Vice Pres.—E. P. Schneider
Sls. Mgr.—A. B. Robinson
Dir. of Custom Sales—D. R. Butler

Structural Fibers, Inc., Chardon

Types of resin and reinforcement used: polyester and phenolic resin; glass and asbestos reinforcement
Number and size of preformers; 30″ Brenner preformer, 36″ open-type flocking machines
Number of presses, platen area, and daylight space of each press: 7 presses, platen sizes from 36″ x 42″ to 52″ x 76″; daylight from 46″ to 70″
Type of fabrication done: seamless glass-reinforced tanks from 3½ to 30 gallon
Vice Pres.—Thomas Harris
Sls. Mgr.—George H. Kaull
Pur. Agt.—H. C. Tolhurst

★Structurlite Plastics Corp., Hebron

Types of molding done and kinds of molds used: glass reinforced plastics: (preforms, mat, premix); silicone; matched metal molds
Types of resin and reinforcement used: polyester and silicone resins; glass roving and mat
Number and size of preformers: 1—24″ automatic, 2—30″ automatics, 1—72″ dia. turntable, 4—30″ dia. turntable
Number of presses, platen area, and daylight space of each press: 16 presses, ranging from 25 to 500 tons cap. with platen areas from 2′ up to 6′ x 6′; daylight space from 24″ to 94″
Types of fabrication done: punching, cementing, and assembly
Personnel: see p. 1175

OKLAHOMA

Fibercast Co., Sand Springs

Types of molding done and kinds of molds used: centrifugal casting of pipe; compression molding of fittings
Types of resin and reinforcements used: braided glass sleeves and fibrous glass cloth; epoxy resin
Number and size of preformers: 55 matched die sets
Number of presses, platen area, and daylight space of each press: 8—24″ x 24″ x 24″
Personnel: see p. 1180

Plastic Engineering Co. of Tulsa, Tulsa

Types of molding done and kind of molds used: Press
Types of resin and reinforcement used: Polyester and epoxy; fibrous glass
Pres.—Daniel M. Byrne
Sls. Mgr.—D. J. Fitzgerald
Pur. Agt.—Leola Wagner

OREGON

Design Industries, Eugene

Types of molding done and kinds of molds used: low pressure presses
Types of resin and reinforcement used: flat, fabric; polyester and epoxy resins
Number of presses, platen area, and daylight space of each press: 2 presses 49″ x 150″
Max. size of flat or corrugated reinforced plastics panel: 50″ x 150″ flat
Type of fabrication done: fabrication of sandwich panels
Pres.—George R. Hermach
Vice Pres.—Raymond Arnold
Project Mgr.—Leroy Holme
Pur. Agt.—Marjorie Zane

PENNSYLVANIA

★American Insulator Corp., New Freedom

Types of molding done and kind of molds used: matched metal molding and hand layup; single member aluminum and wood molds
Types of resin and reinforcement used: polyester and epoxy resins; fibrous glass, sisal, and asbestos reinforcement
Number and size of preformers: 1—36″
Number of presses, platen area, and daylight space of each press: 1—40 ton, 48 x 72 platen, 72″ daylight; 1—80 ton, 48 x 78 platen, 72″ daylight; 1—100 ton, 48 x 48 platen, 108″ daylight
Max. size of flat or corrugated reinforced plastics panel: 36″ x 52″
Type of fabrication done: sawing, routing, drilling, grinding, riveted and bonded assemblies, and silk screening
Personnel: see p. 1175

Chemical Coating & Engineering Co., Inc., Media

Types of molding done and kind of molds used: vacuum
Types of resin and reinforcement used: epoxy; Dacron, fibrous glass
Pres.—Karl Bennung, Jr.
Sls. Mgr.—N. Cartmell
Pur. Agt.—June Bennung

★ Indicates Advertiser

Fiberglass Boat Co., Somerset

Types of molding done and kind of molds used: hand layup
Types of resin and reinforcement used: polyester resin, fibrous glass mat, cloth and roving
Type of fabrication done: large hand layups; boats
Pres.—Edward A. Specht

Hays Mfg. Co., Erie

Types of molding done and kind of molds used: compression (flat sheet), premix
Types of resin and reinforcement used: resins, polyesters, epoxy glass rovings, cloth & mat
Maximum size of flat or corrugated reinforced plastics panel: 36″ x 48″
Pres.—W. H. Forster
Vice Pres.—J. D. Clemens
Sls. Mgr.—H. H. Clemens

McClarin Plastics, Hanover

Types of molding done and kind of molds used: hand lay-up; reinforced plastics molds
Types of resin and reinforcement used: polyesters and epoxies; fibrous glass cloth, roving and mat
Pres., Pur. Agt.—C. G. McClarin
Vice Pres., Sls. Mgr.—R. G. Meckley

Molded Fiber Glass Tray Co., Linesville

Types of molding done and kind of molds used: match metal in hydraulic presses, 2000 psi line
Types of resin and reinforcement used: polyester resins; fibrous glass
Number and size of preformers: 36″ dia. flocking type complete with gas fired oven
Number of presses, platen area, and daylight space of each press: 12—32″ x 40″, 30″ daylight; 3—20″ x 20″, 20″ daylight; 1—24″ x 36″, 28″ daylight
Type of fabrication done: drilling, punching
Pres.—A. W. Levenhagen
Vice Pres., Sls. Mgr.—J. W. More
Pur. Agt.—B. V. Woods

Penn-Plastics Corp., Glenside

Types of molding done and kind of molds used: lay up and impregnated sheets
Types of resin and reinforcement used: glass, cotton fibers; epoxy, phenolic, and polyester resins
Number of presses, platen area, and daylight space of each press: 2—250 ton presses
Personnel: see p. 1176

Perry Plastics, Inc., Erie

Types of molding done and kind of molds used: matched metal molds
Types of resin and reinforcement used: epoxy, polyester; sisal and glass
Number and size of preformers: continuous compounding of pre-mix
Number of presses, platen area, and daylight space of each press: 14 from 24 x 24 to 48″ x 48″
Maximum size of flat or corrugated reinforced plastics panel, if any: 3′ x 4′ max.
Type of fabrication done: complete facilities for finishing
Personnel: see p. 1176

★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim

Types of molding and kind of molds used: compression, bag, and transfer molding; matched metal molds
Types of resin and reinforcement used: high temperature resins of any type; long fiber asbestos reinforcements
Maximum size of flat or corrugated reinforced plastics panel: Flat, 30″ x 72″ and 40″ x 40″

Specht Plastics, Inc., Somerset

Types of molding done and kind of molds used: low-pressure laminated sheet using matched metal dies; fibrous glass preform and premix matched metal dies
Types of resin and reinforcement used: polyester, silicone, epoxy resins; fibrous glass roving and mat
Number and size of preformers: 2—36″; 1—48″
Number of presses, platen area, and daylight space of each press: 1—36″ x 60″, 84″ daylight, 100 ton; 1—48″ x 72″, 84″ daylight, 150 ton, 2—24″ x 24″, 36″ daylight, 50 ton
Maximum size of flat or corrugated reinforced plastics panel: 24″ x 24″; 24″ x 36″
Type of fabrication done: punching, cementing, shearing, and assembly
Pres.—Edward A. Specht

Squires Plastics, Inc., Verona

Types of molding done: compression and transfer molding with steel molds
Types of resin and reinforcement used: fiber glass with phenolic, polyester, and silicone resins
Personnel: See p. 1176

Strick Plastics, Perkasie

Types of molding done and kinds of molds used: press molding
Size of flat laminate sheet made: 4′ x 8′
Gen. Mgr.—H. Weinstein

Ultra Plastics, Inc., Philadelphia

Types of molding done and kind of molds used: vacuum molding; wood, steel, and aluminum
Number and size of preformers: 6—24″ x 36″; several 48″ x 72″
Maximum size of flat or corrugated reinforced plastics panel: 72″ x 72″ corrugated
Type of fabrication done: forming, routing, shaping, and drilling
Pres.—Edward J. Kinslow
Vice Pres., Sls. Mgr.—Donald J. MacDonald
Pur. Agt.—Ralph Owens

United Laminations, Inc., Mayfield

Number of presses, platen area, and daylight space of each press: 1—platen area, 36″ x 36″; 1—platen area, 54″ x 77″, multiple opening; 1—platen area, 36″ x 74″, multiple opening
Personnel: see p. 1182

TENNESSEE

National Plastics, Inc., Knoxville

Types of molding done and kind of molds used: matched steel molds
Types of resin and reinforcement used: sisal mat and phenolic resin; fibrous glass and alkyd
No. of presses, platen area, and daylight space of each press: 2 presses, L to R 24″, F to B 24″, daylight 24″; 2 presses, L to R 26″, F to B 25″, daylight 36″; 2 presses, L to R 31″, F to B 25″, daylight 47″
Personnel: see p. 1177

Plastics Industries, Inc., Athena

Types of molding done and kinds of molds used: vacuum bag with wooden molds and aluminum molds
Types of fabrication done: routing, shaping, drilling, heat forming, turning
Personnel: see p. 1177

TEXAS

Delta Products, Div. of Air Accessories, Inc., Fort Worth

Types of molding done and kind of molds used: hand layup
Type of fabrication done: routing, shaping, drilling, sawing, stamping, bonding, etc.
Pres.—W. I. Spitler, Jr.
Vice Pres.—Wm. K. McConnell, Jr.
Sls. Mgr.—Ray Goudeau
Pur. Agt.—Donald M. Miles

Lone Star Boat Co., Grand Prairie

Types of resin and reinforcement used: polyester

Lone Star Plastics Co., Inc., Fort Worth

Types of molding done and kind of molds used: high and low pressure matched die molding, bag molding, and contact layup; all types of molds used
Types of resin and reinforcement used: polyester, epoxy, silicone, and silastic resins; fibrous glass reinforcements
Number of presses, platen area, and daylight space of each press: 1—30″ x 48″ x 18″; 1—12″ x 18″ x 18″; 1—40″ x 60″ x 14″; 1—12″ x 15″ x 18″; 1—24″ x 24″ x 20″
Maximum size of flat or corrugated reinforced plastics panel: 48″ x 144″
Type of fabrication done: all types necessary
Personnel: see p. 1177

Whitehouse Reinforced Plastic Co., Fort Worth

Types of molding done and kind of molds used: open mold hand layup in a reinforced fibrous glass mold or metal mold
Types of resin and reinforcement used: polyester with fibrous glass reinforcement
Maximum size of flat or corrugated reinforced plastic panel: 26″ x 12′
Pres.—Ben Whitehouse, Jr.
Vice Pres., Engineer:—Charles Wheeler
Sls. Mgr.—Joe Creighton
Pur. Agt.—L. W. Tatum

VERMONT

Newport Plastics Corp., Newport

Types of molding done and kind of molds used: low pressure & high pressure molding with special mold
Types of resin and reinforcement used: polyester and epoxy resins; fibrous glass reinforcement
Number of presses, platen area, and daylight space of each press: 22 special presses up to 36″ x 36″ platen & 48″ daylight
Pres.—J. R. Audet
Pur. Agt.—Paul Beaudry

VIRGINIA

Universal Moulded Products Corp., Bristol

Types of molding done and kind of molds used: vacuum bag; autoclave on metal molds; matched metal molding compounds; open layups for room temperature or oven cure
Types of resin and reinforcement used: polyester, epoxy, phenolic resins; fibrous glass (all forms), asbestos, paper, and sisal reinforcements
Number and size of preformers: 1—36″; 1-72″
Number of presses, platen area, and daylight space of each press: 1—72″ x 72″ x 48″ (80 ton); 3—30″ x 48″ x 72″ (125 ton); 2—30″ x 24″ x 18″ (100 tons); 1—60″ x 60″ x 36″ 1500 ton)
Does continuous laminating
Types of fabrication done: all standard machine operations, plus some specialties
Pres.—T. H. McKoy, Jr.
Vice Pres.—C. L. Meteer
Sls. Mgr.—Robert H. Paschall
Pur. Agt.—J. G. Barnes

WASHINGTON

A & B Plastics, Div. of Plastic Supply Corp., Seattle

Type of resin and reinforcement used: polyester; fibrous glass cloth, and mat
Number and size of preformers: 6—small
Maximum size of flat or corrugated reinforced plastics panel: 48″ x 12′ hand lay-up method

Everlite Corp., Seattle 22

Flat and corrugated polyester-glass panels: max. size, 42″ x 144″
Does continuous laminating

Pacific Plastics Co., Seattle

Types of molding done and kind of molds used: vacuum bag mold with plaster mandrels
Types of resin and reinforcement used: polyesters, epoxies; glass cloth reinforcement
Number of presses, platen area, and daylight space of each press; 2—48″ x 96″, 4′ daylight; 1—36″ x 36″, 2′ daylight; 1—36″ x 36″, 3′ daylight
Type of fabrication done: routing, shaping, drilling, sawing
Personnel: see p. 1180

Rainier Plywood Co., Tacoma

Max. size laminate sheet: 48″ x 96″
Specialize in: phenolic sheet; phenolic overlayed plywood; DAP overlays on wood
Personnel: see p. 1182

WISCONSIN

Gisholt Machine Co., Madison

Number and size of preformers: 3—30″ x 90″
Number of presses, platen area, and daylight space of each press: 5—4′ x 8′ platen, up to 108″ daylight
Max. size of flat or corrugated reinforced plastics panel: 4′ x 8′
Personnel: see p. 1178

Lapcor Plastics, Inc., Manitowoc

Types of molding done and kinds of molds used: matched metal
Types of resin and reinforcements used: polyester, epoxy
Number of presses, platen area, and daylight space of each press: 3 presses, 30″ x 48″ platen, up to 36″ daylight
Personnel: see p. 1178

Lewis Co., G. B., Watertown

Types of molding done and kind of molds used: matched metal dies of Meehanite, and tool steel; custom molding of preform and premixed parts

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★ Indicates Advertiser

Types of resin and reinforcement used: polyester and epoxy resins; glass and other synthetic fibers reinforcement
Number and size of preformers: 8
Number of presses, platen area, and daylight space of each press: 12 from 50 to 200 tons, up to 48" x 72" platen area, 106" daylight, 66 stroke
Personnel: see p. 1178

Portz Plastics & Fibre Co., Milwaukee
Types of molding done and kind of molds used: hand layup; wood and metal molds
Types of resin and reinforcement used: polyester resin; fibrous glass reinforcement
Pres., Pur. Agt.—Chas. A. Portz
Vice Pres.—M. Mueller
Sls. Mgr.—R. T. Chop

ENGLAND

British Moulded Plastics, Ltd., London
Types of molding done and kind of molds used: matched metal molding
Number and size of preformers: 1—Brenner; 2—Turner Atherton
Number of presses, platen area, and daylight space of each press: 2—4′ x 3′ platen; 6′ daylight; 2—30" x 24" platen; 3′ daylight
Personnel: see p. 1178

NORWAY

Aksjeselskapet Ancas, Arendal
Types of molding done and kind of molds used: low-pressure matched die molding, bag and vacuum (Marco) molding, contact layup. All type molds
Types of resin and reinforcement used: polyester and epoxy resins; glass cloth, mat, and roving
Type of fabrication done: specializes in boats and industrial articles
Pres.—A. N. Christensen
Vice Pres.—Terje S. Lunder
Sls. Mgr.—R. P. Anderson
Pur. Agt.—O. Rasmussen

Thermoplastic Sheet Formers

CALIFORNIA

Blackman Plastics, Culver City

*__Calresin Co., Div. of Knudsen Creamery,__ Los Angeles
Number of sheet forming machines: 1
Specialize in: Containers
Personnel: see p. 1163

*__Chemtron Fiber Glass Co.,__ El Monte
Number of sheet forming machines: 4
Type of machine: pressure, vacuum, etc.
Specialize in: unusual items
Personnel: see p. 1163

*__Engineering Plastics Co.,__ Pasadena
Number of sheet forming machines: 10
Type of machine: vacuum, pressure, slip, snap back, wrap around
Specialize in: Deep draws, precision parts, including metal assembly
Pres. & Sales Mgr.—W. Kenneth Peasley
Pur. Agt.—Russel Gilbert

*__Falcon, Inc.,__ Santa Monica
Number of sheet forming machines: 15
Type of machines: Air and hydraulic; hydraulic
Specialize in: Material handling and packaging boxes and trays; industrial custom forming
Pres.—Norman Lapworth
Vice Pres. & Sls. Mgr.—Paul Weigl
Pur. Agt.—H. W. Trumpler

*__Hollywood Plastics Inc.,__ Los Angeles
Number of sheet forming machines: 18
Type of machine: Pressure and slip
Specialize in: Material's handling boxes
Pres.—Fred Nascher
Vice Pres.—Alice Nascher
Sls. Mgr.—Andy Spiegl
Pur. Agt.—Sam R. Berg

Plastic Model Engineering, Van Nuys
Number of sheet forming machines: 1
Type of machine: 18" x 18" drape-vacuum forming
Specialize in: Samples
Personnel: see p. 1164

Ray Products Co., Inc., Alhambra
Number of sheet forming machines: 2
Type of machine: 1—20 x 50; 1—18 x 18 with plug assist
Specialize in: Custom forming and fabrication of thermoplastics

★*__Sierra Electric Corp.,__ Gardena
Number of sheet forming machines: 2
Type of machine: pressure, vacuum
Specialize in: Forming polyester, acrylic, polystyrene sheets
Personnel: see p. 1164

★*__Swedlow, Inc.,__ Los Angeles
Specialize in: Acrylic/polyester; stretched acrylic; forming and fabricating
Personnel: see p. 1178

Urrite Plastics Fabricators, Pico Rivera
Specialize in: Custom forming to users' specifications
Personnel: see p. 1181

COLORADO

Denver Plastics, Inc., Golden

*__Sawaya Manufacturing Co., Inc.,__ Trinidnd
Number of sheet forming machines: 4
Type of machine: 1—12 x 12, 1—twin 24 x 30, 1—Roll 28 x 32, 1—48 x 96
Specialize in: Custcm forming
Personnel: see p. 1164

*__Seder Plastic Corp.,__ Ft. Collins
Number of sheet forming machines: 1
Type of machine: Vacuum
Personnel: see p. 1164

CONNECTICUT

*__Sealy Plastics Corp.,__ Rockville
Number of sheet forming machines: 3
Type of machine: Combination of vacuum, pressure, etc.
Specialize in: High-impact materials, e.g. ABS sheet, up to ⅜" thick
Pres., Sls. Mgr., Pur. Agt.—Seymour E. Lavitt
Vice Pres.—Edith H. Lavitt

*__Valley-National Corp., The,__ Milldale
Number of sheet forming machines: 8
Type of machine: vacuum, pressure, air slip, mechanical
Specialize in: packaging, displays, housings, covers, trays, bubbles, and blisters
Pres.—H. R. Sterrett
Vice Pres.—W. J. B. Johnson
Sls. Mgr.—John Reese
Pur. Agt.—W. D. Ferguson

★*__Watertown Mfg. Co., The,__ Watertown
Personnel: see p. 1165

FLORIDA

*__Modern Plastics,__ Miami
Number of sheet forming machines: 2
Types of machine: Pressure, vacuum, hydraulic ram
Specialize in: Heavy sheet A.B.S., acrylic, tote boxes, and aircraft parts
Gen. Mgr., Sls. Mgr.—Geo. H. Light
Dir. of Engineering—R. E. Ford
Pur. Agt.—D. Duffield

*__Southern Plastic Products Co.,__ Riviera Beach
Number of sheet forming machines: 2
Type of machine: Vacuum, pressure, and drape
Specialize in: Package components (formed blisters; skin packages; formed pads; and point-of-sales)
Personnel: see p. 1184

GEORGIA

*__Gladwin Plastics, Inc.,__ Atlanta
Number of sheet forming machines: 7
Type of machine: 4—plug and ring; 3—vacuum, drape, plug and ring
Specialize in: lighting fixtures, signs, telephone booths, display cases
Pres.—C. A. Evans
Vice Pres., Sales Mgr.—Ralph F. Chambers
Pur. Agt.—H. F. Loring

*__Plastic Fabricants, Div. of The Woodman Co., Inc.,__ Decatur
Number of sheet forming machines: 1
Type of machine: Pressure and vacuum
Specialize in: Vacuum forming, pressure forming, custom work
Personnel: see p. 1185

ILLINOIS

*__Arrem Plastics, Inc.,__ Chicago
Number of sheet forming machines: 9
Type of machine: All techniques for deep drawing
Specialize in: deep drawing acrylic and copolymer sheet
Pres., Pur. Agt.—R. U. Muhlethaler
Vice Pres., Sls. Mgr.—H. J. Dibblee

*__Bacon & Weber,__ Chicago
Number of sheet forming machines: 1
Type of machine: Plug, vacuum, pressure comb.; 42" x 42"
Personnel: see p. 1185

★*__Carroll Co., J. B.,__ Chicago
Number of sheet forming machines: 3
Type of machine: Special machine, own design
Specialize in: Signs, displays, industrial parts
Personnel: see p. 1179

*__Consolidated Plastics & Mfg. Co.,__ Chicago
Number of sheet forming machines: 2
Type of machine: Vacuum forming

*__Continental Plastic Corp.,__ Chicago
Type of machine: Pressure
Specialize in: Custom work
Personnel: see p. 1165

*__I-V Die Mold Co.,__ Peoria
Number of sheet forming machines: 3
Type of machine: Drape and/or air slip
Specialize in: industrial components, hearing aids, photo equipment

*__Plastofilm, Inc.,__ Wheaton
Number of sheet forming machines: 8
Type of machine: Pressure, vacuum, and matched
Specialize in: Packaging
Pres.—George Wiss
Vice Pres.—Vera Wiss
Sls. Mgr.—Leonard Seeley
Pur. Agt.—Max Benaroyo

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* Operates own tool room
★ Indicates Advertiser

***Stensgaard & Associates, W. L., Inc.,** Chicago
Number of sheet forming machines: 2
Type of machine: Vacuum Forming

★*United States Rubber Co., Royalite Div., Chicago
Number of sheet forming machines: 80
Specialize in: Volume custom forming
Pres.—J. W. McGovern
Vice Pres.—C. W. Pennington
Sls. Mgr.—T. R. Grimes

Waltco Products, Inc., Chicago
Specialize in: Vacuum forming
Pres., Sls. Mgr.—Sidney J. Klein
Vice Pres., Pur. Agt.—Edw. Vandris

***Wessel, Stanley, & Co.,** Chicago
Number of sheet forming machines: 8
Type of machine: Special
Specialize in: Point-of-Sale Displays
Pres.—Stanley L. Wessel
Vice Pres.—William J. Higgins

INDIANA

***Borkland Mfg. Co.,** Marion
Number of sheet forming machines: 10
Type of machine: Pressure; vacuum; air slip; mechanical forming; fusion
Specialize in: Industrial; lighting; toys; packaging; tubes; tubs; barrels; boxes; building materials

★*General Plastics Corp., Marion
Number of sheet forming machines: 10
Type of machine: All types
Specialize in: Sheet extrusion and fabricating of styrene and butyrate rigid sheet
Personnel: see p. 1167

Kent Plastics Corp., Evansville
Number of Sheet Forming Machines: 5
Type of Machine: Vacuum forming
Specialize in: Refrigerator inner doors; High volume packaging
Personnel: see p. 1167

***Plast-Ad Mfg. Co.,** South Bend
Type of machine: 4—Air pressure; 1—vacuum forming; 1—hydraulic
Specialize in: Forming plastic letters, signs, displays, etc.
Pres., Sls. Mgr.—Peter A. Gadomski
Vice Pres., Pur. Agt.—C. M. Gadomski

IOWA

Timely Products Co., Des Moines

KANSAS

***Plastic Fabricating Co., Inc.,** Wichita
Number of sheet forming machines: 1
Type of machine: 30 x 36 Automatic vacuum former
Specialize in: Boltaron, Royalite, acrylic sheet
Personnel: see p. 1185

LOUISIANA

***Plastic Suppliers and Manufacturers,** Baton Rouge
Number of sheet forming machines: 3
Type of machine: Pressure, vacuum
Pres., Sls. Mgr.—L. H. Hyland
Vice Pres.—E. Labasse
Pur. Agt.—J. L. Hyland

MARYLAND

***Artmor Plastics Corp.,** Cumberland
Number of sheet forming machines: 5
Type of machine: Pressure, air slip, vacuum, etc.
Specialize in: Textile mill parts, electrical insulations, industrial components, building materials development

***Falge Engineering Corp.,** Bethesda
Number of sheet forming machines: 10
Type of machine: Pressure, air, mechanical, hydraulic
Specialize in: Packaging & insulation, forms for electric and electronic industries

***Fawn Plastics Co., Inc.,** Timonium
Number of sheet forming machines: 3
Type of machines: 1—Air slip; 2—pressure
Specialize in: Luggage shells
Personnel: see p. 1167

***Wama Co., The,** Baltimore
Number of sheet forming machines: 1
Type of machine: pressure
Specialize in: acrylic forming
Personnel: see p. 1167

MASSACHUSETTS

***Crook Co., William A., Inc.,** Watertown
Number of sheet forming machines: 7
Pres., Sls. Mgr.—William A. Crook

***Duplicon Company, Inc.,** Westboro
Number of sheet forming machines: 10
Type of machines: Pressure; vacuum; vacuum, snap back, and pressure combinations; semi-automatic
Specialize in: Industrial housings; materials handling trays; machine components; and protective covers

***Gregstrom Corp.,** Cambridge
Number of sheet forming machines: 10
Type of machine: 2—drape; 1—pressure; 1—air slip; 6—ring and plug
Specialize in: Custom thermoforming for industrial applications
Pres.—George M. Naylor
Sales Mgr. & Gen. Mgr.—Louis DiDonato
Pur. Agt.—E. E. Rugg

***Mercury Plastics Corp.,** Chicopee
Number of sheet forming machines: 14
Type of machine: Pressure, Air Slip, Vacuum
Specialize in: Tote trays, protective covers, machine covers, and cases
Pres., Sls. Mgr.—Lawrence W. Leonard
Pur. Agt.—Veronica V. Leonard

***Monkley Corp.,** Worcester

Rome Plastic Specialties, Inc., Worcester
Number of sheet forming machines: 2
Specialize in: Acetate boxes
Pres.—Harold D. Rome
Treas., Pur. Agt.—Richard Rome

***Wasco Products, Inc.,** Cambridge
Number of sheet forming machines: 40
Type of machine: Plug and ring, and vacuum
Personnel: see p. 1186

MICHIGAN

Acme Laminating & Plastics Co., Inc., Detroit
Type of machine: 1—40" x 50", 3—special units 24" x 24"
Specialize in: industrial parts, arm rest, crash pads, vacuum formed signs
Personnel: see p. 1179

***Ameriplastic Co., The,** Flint
Number of sheet forming machines: 3
Type of machine: 4' x 8' 10" draw, 4' x 8' 32" draw air presses, 1—vacuum former 30" x 36" semi-automatic
Specialize in: acrylic air presses; miscellaneous vacuum formers
Personnel: see p. 1186

★*Cadillac Plastic & Chemical Co., Detroit
Number of sheet forming machines: 12
Type of machine: all types
Personnel: see p. 1168

★*Capitol Plastics Co., Lansing

Darling, L.A., Co., Plastic Div., Coldwater

***Fabri-Kal Corp.,** Kalamazoo
Number of sheet forming machines: 7
Type of machine: 4 air cylinder ram presses, 1 pressure forming, 2 roll feedplug assist or vacuum forming automatics
Specialize in: Packaging
Pres.—R. P. Kittredge
Sls. Mgr.—R. G. Pierce
Pur. Agt.—M. A. Klein

***General Machine & Tool Works,** Walled Lake
Number of sheet forming machines: 2
Type of machine: pressure and air slip

***Imperial Industries, Inc.,** Wayne
Type of machine: Vacuum forming, plug and ring, pressure forming
Specialize in: Acrylic, high impact polystyrene, ABS copolymers, rigid vinyls, polyolefins & cellulosics
Pres. and Pur. Agt.—W. K. Lewellen, Jr.
Vice-Pres.—Charles O. Betz
Sls. Mgr.—R. W. Struthers

***Klise Manufacturing Co.,** Grand Rapids
Number of Sheet Forming Machines: 4
Type of Machine: Pressure, air, vacuum
Specialize in: Materials handling applications; Acrylic dome skylights; Industrial components
Pres. & Sls. Mgr.—James C. Veen, Jr.
Vice Pres. & Pur. Agt.—John P. Veen

***Reynolds Plastics, Inc.,** Walled Lake
Number of sheet forming machines: 2
Type of machine: Twin table, air slip; 1 Pressure
Specialize in: Experimental model making (prototypes)
Personnel: see p. 1169

***Woodall Industries, Inc.,** Detroit
Number of sheet forming machines: 8
Type of machine: Rotary multi-station high speed plug assist; air slip
Specialize in: Custom molded fabricated thermoplastics
Personnel: see p. 1169

***Zenith Plastics of Michigan, Inc.,** Ypsilanti
Number of sheet forming machines: 3
Type of machine: vacuum
Specialize in: Industrial Production Parts
Pres.—K. D. Bauer
Vice Pres.—Alfred Deotte
Sls. Mgr.—Henry Jones
Pur. Agt.—Don Faust

MINNESOTA

***Mankato Paper Box Co.,** Mankato
Number of sheet forming machines: 6
Type of machine: Vacuum and Pressure

***North Star Industries, Inc.,** Hopkins
Number of sheet forming machines: 1
Type of machine: Vacuum forming
Specialize in: Blister packages, display signs
Personnel: see p. 1169

***Plastics, Inc.,** St. Paul
Number of sheet forming machines: 14
Type of machine: Pressure, plug assist, air slip, straight vacuum
Specialize in: Custom vacuum forming applications
Personnel: see p. 1169

***Premier Plastic Manufacturing Co.,** Minneapolis
Number of sheet forming machines: 4
Type of machine: 1—pressure forming machine, 3—vacuum forming machines
Specialize in: custom forming and fabricating of thermoplastics
Pres., Sls. Mgr.—Arthur F. Bush
Pur. Agt.—Norman Reid

***Thunderbird Plastics, Inc.,** Minneapolis
Type of machine: 1 vacuum forming machine, two beds 48" x 72"

MISSOURI

***Regal Plastic Co.,** Kansas City
Number of sheet forming machines: 22
Type of machine: Pressure, slip-forming, and blow-back
Specialize in: Deep draws, large size intricate forms, turned-in-edge shells
Personnel: see p. 1186

NEW JERSEY

***Atti Engineering Corp.,** Union City
Number of sheet forming machines: 4—up to 36" x 60"
Type of machine: Pressure
Specialize in: Heavy gage (1/16 to ½") ABS, high-impact styrene, vinyl, etc., for housings and tote boxes

Colvin-Friedman Co., Springfield
Number of sheet forming machines: 8
Type of machine: Pressure, vacuum forming
Specialize in: Windows, insulators, cable clamps, and electronic components
Pres.—Henry F. Colvin
Sls. Mgr.—S. H. Friedman
Pur. Agt.—J. F. Sweeney

***Efka Plastic Corp.,** Hoboken
Number of sheet forming machines: 4
Type of machines: Vacuum
Specialize in: Materials for handbag and novelty trade
Personnel: see p. 1195

★*Emeloid Co., The, Inc., Hillside
Number of sheet forming machines: 1
Type of machine: vacuum forming, 26" x 30"
Specialize in: containers, displays, blisters, etc.
Personnel: see p. 1170

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* Operates own tool room
★ Indicates Advertiser

*Madan Plastics, Inc., Cranford
Number of sheet forming machines: 6
Type of machine: Pressure, vacuum
Specialize in: Deep draws, decorative displays
Personnel: see p. 1171

*Palisades Plastics Co., Inc., Englewood
Number of sheet forming machines: 6
Types of machines: vacuum, pressure only, vacuum and pressure
Specialize in: general vacuum forming all materials, free blowing
Pres.—Frank J. Van Segvelt
Vice Pres., Sls. Mgr., Pur. Agt.—Theodore Fotos

*Pantasote Co., The, Passaic
Number of sheet forming machines: 2
Type of machine: Vacuum
Specialize in: Packaging material
Pres. Hans Wyman
Vice Pres.—. D. Foley, S. D. Maloney
Sls. Mgr.—Max Blutman, W. E. Browning, R. F. Hill
Pur. Agt.—J. Gutschalk, E. D. Randall

*Pitman Plastic Products, Inc., Pitman
Number of sheet forming machines: 4
Type of machine: Vacuum and drape
Specialize in: Sprayed metal, plastic, and wooden molds
Personnel: see p. 1187

*Polytex Corp., Hoboken
Number of sheet forming machines: 4
Type of machine: Vacuum forming
Specialize in: Decorative and 3-dimensional sheets for the handbag and novelty trade
Personnel: see p. 1195

*Preservation Packaging, Inc., Hillside
Number of sheet forming machines: 3
Type of machine: Drape and vacuum forming
Specialize in: Skin packaging; blister forming and packaging; materials handling trays, packaging inserts
Pres.—Norton Agriss
Vice Pres.—J. L. Fallick
Pur. Agt.—D. A. Zazzali

S-L-M Plastics, Avenel
Number of sheet forming machines: 9
Specialize in: Acetate containers
Pres.—Dr. Joseph Vattay
Vice Pres.—Stephen M. Vattay
Sls. Mgr., Pur. Agt.—Leslie Vattay

Sanford Plastics Corp., Matawan
Number of sheet forming machines: 1
Personnel: see p. 1171

Springfield Fabricators, Inc., Springfield
Number of sheet forming machines: 8
Type of machine: Pressure, vacuum forming
Specialize in: Windows, insulators, cable clamps, and electronic components
Pres.—Henry F. Colvin
Sls. Mgr.—S. H. Friedman
Pur. Agt.—J. F. Sweeney

NEW YORK

*A.A.A. Plastic Co., New York
Number of sheet forming machines: 4
Type of machines: Straight vacuum; plug and ring; drape, etc.
Specialize in: Custom work only
Personnel: see p. 1172

*Aacon Industries Inc., Brooklyn
Number of sheet forming machines: 10
Type of machine: vacuum formers, hydraulic air pressure forming etc., handle sheets from .005" to 1" thick, 48" to 72"
Personnel: see p. 1172

*A.B.S. Mfg. Co., Inc., New York
Number of sheet forming machines: 3
Type of machines: 4 pressure; 1 Vacuum and Pressure
Specialize in: Custom work

*Alda Plastics Inc., New York
Number of sheet forming machines: 2
Specialize in: vacuum forming, drawing all materials
Pres.—Meyer Moch
Sls. Mgr.—Julie Rothman

*Art Plastics Co., Woodside
Type of machine: 9—press; 2 airslip
Specialize in: Displays, artistic and commercial; enclosures

*Bo-Mer Mfg. Co., Inc., Auburn
Number of sheet forming machines: 1—4' x 8' press; 2—3' x 6' presses
Specialize in: styrene, buytrate, acetate, ABS, vinyl; door liners to blister packs

Chanal Plastics Corp., Rego Park

*Custom Merchandise Corp., Brooklyn
Number of sheet forming machines: 2
Type of machine: Vacuum
Specialize in: Industrial parts, displays, and packaging
Pres., Pur. Agt.—Sheldon Oshin
Vice Pres., Sls. Mgr.—Norman Oshin

★*DeWitt Plastics Div., Shoe Form Co., Inc., Auburn
Number of sheet forming machines: 10
Type of machine: 3 Vacuum forming machines; 7 slip ring forming machines
Specialize in: Development and prototype for industrial applications as well as production runs
Personnel: see p. 1172

*Durable Formed Products, Inc., New York
Number of sheet forming machines: 21
Type of machines: Vacuum forming, pressure forming, air slip forming, etc.
Specialize in: Thermoforming of rigid thermoplastic sheeting, such as acrylic, ABS polymer, polyethylene, and high-impact styrene
Pres.—Vito A. Tanzi
Dir. of Engrg.—Gilbert G. D'Andrea
Prod. Mgr.—Jack Aragona
Pur. Agt.—Thomas McManus

Dura Plastics of New York, Inc., New York
Number of sheet forming machines: 5
Types of machines: 2 Vacuum forming; 3 Pressure forming
Specialize in: Fabrication
Pres.—Joseph Layman
Vice Pres., Pur. Agt.—Dorothy Wexler
Sls. Mgr.—Samuel Baliner

*Emerson Plastics Corp., Bronx
Number of sheet forming machines: 4
Type of machine: Vacuum forming; drape forming; snapback; pressure forming, blowing
Specialize in: Industrial applications
Personnel: see p. 1172

*Gemloid Corp., Long Island City
Personnel: see p. 1172

*Industrial Sales Engineers, New York
Number of sheet forming machines: 3
Type of machine: Ring & plug-drape-vacuum
Specialize in: Custom, industrial, display, trays, etc.
Personnel: see p. 1173

Industrial Transparent Products Corp., Freeport
Number of sheet forming machines: 3
Type of machine: straight vacuum and drape
Specialize in: clear blisters in cellulose acetate

*Injection Molding Corp., New York
Number of sheet forming machines: 3
Type of machine: Vacuum-forming
Specialize in: Packaging, blisters & toy components
Personnel: see p. 1173

*Jodee Plastics, Inc., Brooklyn
Number of sheet forming machines: 2
Type of machines: Low-pressure; air slip
Personnel: see p. 1173

*Just Plastics, Inc., New York
Number of sheet forming machines: 5
Specialize in: Using ⅛"-thick or heavier sheet; sheet sizes up to and including 102" x 120"
Pres.—Charles Vermann
Sales Mgr., Pur. Agt.—Martha Turi

*Lee-Hy Plastics, Inc., Buffalo
Number of sheet forming machines: 3
Type of machine: Vacuum
Specialize in: Blister packaging, box inserts; vacuum formed industrial parts
Pres.—Hyman Pleskin
Vice Pres.—Leo Jankowski
Sls. Mgr.—Ken Pierce

*Majestic Creations, Inc., Woodside
Number of sheet forming machines: 5
Type of machine: Straight vacuum forming and drape forming
Specialize in: Preprinting plastic and then forming
Pres., Sales Mgr.—Ben J. Seger
Vice Pres.—Philip Carlton
Pur. Agt.—Seymour Silverman

*Merchandise Presentation, Inc., New York
Number of sheet forming machines: 10
Type of machine: Vacuum formers for snap back forming process
Specialize in: Drawers and trays (Acrylic)
Pres.—Hyman Charnin
Sls. Mgr.—Seymour C. Falek
Pur. Agt.—M. Engel

*Plastic Artisans, Inc., Port Chester
Number of sheet forming machines: 6
Type of machine: Special automatic pressure machines high speed
Specialize in: Packaging and component parts
Pres. & Sls. Mgr.—C. W. Middleton Jr.
Pur. Agt.—Geo. Trehuhenko

*Plastic Center, Rochester
Number of sheet forming machines: 1
Type of machines: Vacuum former
Specialize in: Samples, models, short runs
Personnel: see p. 1182

*Plastic Enterprises, College Point
Number of sheet forming machines: 5
Type of machine: drape forming, plug forming
Specialize in: Blisters, toy parts, merchandising displays, lighting panels, industrial parts
Pres., Pur. Agt.—Norman Zwiebel
Vice Pres.—Herbert A. Brandon
Sls. Mgr.—William Ruskin

Plasticite Corp., New York
Number of sheet forming machines: 2
Personnel: see p. 1173

*Plasti-Skill Co., Corona
Number of sheet forming machines: 2
Type of machine: Pressure
Specialize in: Packaging
Personnel: see p. 1187

*Plaxall, Inc., Long Island City
Number of sheet forming machines: 16
Type of machine: Pressure
Specialize in custom work
Pres.—Louis H. Pfohl
Vice Pres.—James M. Pfohl

*Robinson, Lewis & Rubin, Inc., New York
Number of sheet forming machines: 5
Type of machine: 2—vacuum formers, 3—pressure formers
Specialize in: Lighting products, industrial cases and housings

*Silicone Insulation, Inc., Bronx
Number of sheet forming machines: 4
Type of machine: Vacuum forming, drape forming, snapback, pressure forming, blowing
Specialize in: Industrial applications
Personnel: see p. 1173

*Syracuse Plastic Molders, Syracuse
Number of sheet forming machines: 2
Type of machine: Drape and vacuum thermoforming: pressure-air slip; snapback
Specialize in: Blisters, industrial parts
Partners—J. R. Falcone, Anthony Falcone, Jr.

*Techni-Plastics, Inc., Pt. Washington
Number of sheet forming machines: 6
Type of machine: Pressure forming, plug assist, stretch forming, etc. of thermoplastic sheeting
Specialize in: Sheet forming of acrylic, ABS, and styrene
Pres.—Vito A. Tanzi
Sls. Mgr.—Robert A. Gorardi
Vice Pres.—Walter R. Speck
Pur. Agt.—Thomas McManus

*Tico Plastics, Inc., New York
Number of sheet forming machines: 4
Type of machine: Vacuum & drape forming
Personnel: see p. 1173

*United Mask & Novelty Co., Inc., Glendale
Number of sheet forming machines: 4
Type of machine: 3—drape, max. 36" x 48"; 1—4 position straight vacuum
Specialize in: Custom forming of displays, containers, toys, and novelties
Personnel: see p. 1173

*Whyte Mfg. Co., Inc., New York
Number of sheet forming machines: 3
Type of machine: Vacuum forming
Specialize in: Packaging, blisters and toy components
Personnel: see p. 1173

NORTH CAROLINA

*Fair Martin Boxes, Inc., Concord
Number of sheet forming machines: 1
Type of machine: Drape
Specialize in: Plastic packaging including

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* Operates own tool room
★ Indicates Advertiser

combination set-up paper board tray and blister-type cover, also creased and corner sealed acetate lids
Pres.—L. F. Martin
Sls. Mgr. and Pur. Agt.—Roy G. Harvey

Engineered Plastics, Inc., Gibsonville

OHIO

***American Agile Corp.,** Bedford
Specialize in: Plastic fabrications
Personnel: see p. 1174

★**Barron Plastics, J. E., Inc.,** Cincinnati
Number of sheet forming machines: 1
Type of machine: Pressure form
Specialize in: Acrylic forming
Personnel: see p. 1174

***Electro-Chemical Products,** Cleveland
Number of sheet forming machines: 2
Types of machine: Oil (hot) machines for forming thermoplastic sheet material
Specialize in: Forming PVC (polyvinyl chloride)

***Fabri-Form Co., The,** Byesville
Number of sheet forming machines: 8
Specialize in: Parts for industrial use
Pres.—J. W. Knight
Vice Pres. & Sls. Mgr.—R. L. Baker
Pur. Agt.—E. E. Wray

Hopple Plastics, Inc., Cincinnati
Number of sheet forming machines: 3
Type of machine: Vacuum and pressure
Pres., Sls., Mgr.,. Pur. Agt.—John S. Hopple
Vice Pres.—John S. Minor

***Plastic Parts Corp.,** Maumee
Number of sheet forming machines: 3
Type of machine: Vacuum and plug assist
Pres.—W. F. Broer
Vice Pres.—D. L. Lambert, Jr.

Plastic Products Corp., Bedford Heights
Number of sheet forming machines: 1
Types of machine: Vacuum former
Specialize in: Floral planters
Personnel: see p. 1188

***Vacuum Plastics Corp.,** Columbus
Number of sheet forming machines: 3
Type of machine: Vacuum
Specialize in: Custom molding of various industrial and home appliance parts
Personnel: see p. 1175

***Vlchek Tool Co., The,** Cleveland
Number of sheet forming machines: 1
Type of machine: Drape former, 42″ x 72″
Specialize in: High-impact styrene
Personnel: see p. 1175

OKLAHOMA

***Fibercast Co.,** Sand Springs
Personnel: see p. 1188

Plastic Engineering Co. of Tulsa, Tulsa
Number of sheet forming machines: 1
Type of machine: Press
Specialize in: Acrylic skylights
Personnel: see p. 1188

PENNSYLVANIA

***Contour Packaging Co.,** Philadelphia
Number of sheet forming machines: 3
Type of machine: Pressure and vacuum forming
Specialize in: Skin packaging, pressure forming, and vacuum forming
Personnel: see p. 1182

***Curry Arts,** Scranton
Number of sheet forming machines: 1
Type of machine: Pressure
Personnel: see p. 1176

Halsen Mfg. Co., Philadelphia

McClarin Plastics, Hanover
Personnel: see p. 1189

***Pearson-Sutton Corp.,** Bucks County
Number of sheet forming machines: 5
Type of machine: Blanket size 52″ x 84″
Specialize in: High-impact styrene, vinyl, acrylic, ABS, and butyrate forms

***Port Erie Plastics, Inc.,** Erie
Number of sheet forming machines: 3

Reinhardt Co., J. A., Mountain Home
Type of machine: 2—24″ x 36″
Specialize in: Industrial heavy-gauge forming
Pres.—John A. Reinhardt, Jr.
Vice Pres.—John A. Reinhardt, Sr.
Sls. Mgr.—Robert Reinhardt
Pur. Agt.—Charles Ayers

***Thomas, Charles W., Inc.,** Philadelphia
Number of sheet forming machines: 2
Type of machine: Vacuum forming
Pres.—Charles W. Thomas
Vice Pres., Pur. Agt.—J. T. Craig
Sls. Agt.—J. H. Costello

RHODE ISLAND

***Tupper Co.,** Woonsocket
Specialize in: Custom vacuum forming
Personnel: see p. 1176

***Shaw-Randall Co., Inc.,** Pawtucket
Number of sheet forming machines: 8
Type of machine: Vacuum and pressure
Specialize in: Packaging made of all rigid sheet materials
Pres.—Charles K. Shaw
Sls. Mgr.—C. Knowlton Shaw, Jr.
Pur. Agt.—E. S. Lancaster

TENNESSEE

Kusan, Inc., Nashville
Number of sheet forming machines: 1
Specialize in: Blister packages
Personnel: see p. 1177

Plastics Industries, Inc., Athens
Number of sheet forming machines: 3
Type of machines: 1—22″ x 52″, 1—40″ x 40″, 1—14″ x 14″ vacuum machines
Specialize in: Blister and skin packs, heat forming for special shapes
Personnel: see p. 1177

TEXAS

***Delta Products, Div. of Air Accessories, Inc.,** Fort Worth
Number of sheet forming machines: 7
Type of machine: 5 automatic, complete combination; 2 automatic, vacuum ring
Specialize in: Heavy-gage forming 1/32″ to ½″; maximum size parts tooled for 100″ x 120″
Personnel: see p. 1189

***Electro Plastics Corp.,** Dallas
Number of sheet forming machines: 4
Types of machine: 1—vacuum; 1—air slip; 2—drape
Specialize in: Displays, lighting diffusers, and industrial components
Personnel: see p. 1177

***Lone Star Plastics Co., Inc.,** Fort Worth
Number of sheet forming machines: 1
Type of machine: Vacuum, plunger
Specialize in: Instrument cases, industrial applications
Personnel: see p. 1177

Plastics Center of Texas, San Antonio
Number of sheet forming machines: 2
Types of machines: Vacuum, pressure
Specialize in: Signs and displays
Partners—Ovidio Flores, Ernest Cavazos
Sls. Mgr.—O. Flores, Jr.
Pur. Agt.—Ernest Cavazos

VERMONT

Manchester Molding Co., Manchester Depot
Number of sheet forming machines: 1
Type of machine: Air slip
Personnel: see p. 1177

VIRGINIA

***O'Sullivan Rubber Corp.,** Winchester
Number of sheet forming machines: 12
Type of machine: Vacuum, drape, plug; combination plug-pressure
Specialize in: Automotive parts, luggage, industrial use parts
Personnel: see p. 1177

WASHINGTON

***General Plastics Mfg. Co.,** Tacoma
Number of sheet forming machines: 2
Specialize in: Acrylic aircraft windows, particularly multi-axially stretched; formed acrylic outdoor signs
Pres.—L. W. Schatz

Pacific Plastics Co., Seattle
Number of sheet forming machines: 1
Type of machine: pressure, vacuum
Specialize in: vinyl forming
Personnel: see p. 1180

WEST VIRGINIA

***Plastics by . . . Hoover,** Huntington
Number of sheet forming machines: 2
Type of machine: 20″ x 20″ vacuum machines
Specialize in: 3-D displays
Personnel: see p. 1177

WISCONSIN

***Bostrom Corp.,** Milwaukee
Number of sheet forming machines: 1
Type of machine: Vacuum forming
Specialize in: Cushion covers, crash pad covers, etc.
Personnel: see p. 1180

***Evans-Zeier Plastic Co.,** Madison
Number of sheet forming machines: 1
Type of machine: 60″ x 72″ drape vacuum machine
Personnel: see p. 1177

***National Plasticrafters, Inc., (Sub. of National Lock Co.),** Sheboygan
Number of sheet forming machines: 1
Type of machine: Vacuum-drape forming automatics
Personnel: see p. 1178

★***Portage Plastics Co.,** Portage
Number of sheet forming machines: 3
Type of machine: vacuum
Personnel: see p. 1178

***Premier Plastics Co.,** Milwaukee
Number of sheet forming machines: 6
Type of machine: All types of pressure differential processes
Specialize in: Industrial parts
Pres.—Robert W. Ray
Vice Pres.—Wm. R. Ross
Pur. Agt.—Merry Blatnik

Presco Plastics, Milwaukee
Number of sheet forming machines: 4
Type of machine: high pressure
Personnel: see p. 1178

Tewes Plastics Corp., Wankesha
Number of sheet forming machines: 4
Type of machine: Vacuum-pressure
Specialize in: Heavy gage plastics
Pres.—Donald E. Tewes

Trim Molded Products Co., Inc., Burlington
Type of machine: 1 drape vacuum former, 18″ x 48″; 1 drape vacuum former, 42″ x 72″
Personnel: see p. 1178

***Western Coil & Electrical Co.,** Racine
Type of machine: One vacuum forming press 15″ x 22″; one vacuum forming press 22″ x 44″
Personnel: see p. 1178

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* Operates own tool room
★ Indicates Advertiser

Slush Molders and Rotational Casters

(Vinyl Plastisols, Polyethylene, etc.)

A. *Rotational Casting*
B. *Slush Molding*

CALIFORNIA

Chemtron Fiber Glass Co., El Monte (B)
Personnel: see p. 1183

Westech Engineering, Santa Clara (A)

COLORADO

Sawaya Manufacturing Co., Inc., Trinidad (A, B)
Personnel: see p. 1164

Things, Inc., Denver (B)
Pres., Pur. Agt.—Rollen E. Brown
Vice Pres.—H. B. Brown

CONNECTICUT

Eastern Moulded Prod. Co., S. Norwalk (A, B)
Pres., Sls. Mgr.—Frederick H. Schavoir

GEORGIA

Flexible Products Co., Marietta (A, B)
Pres. & Sls. Mgr.—R. T. Henson
Vice Pres.—D. B. Henson
Pur. Agt.—L. H. Collins

Pasley's Plastic Products, Inc., Atlanta (A, B)
Pres.—A. P. Rushton
Vice Pres.—J. P. Phillips
Sls. Mgr., Pur. Agt.—J. P. Phillips

ILLINOIS

Plastic Rotocast Co., Chicago (A)
Pres., Pur. Agt.—Bruce Evens
Vice Pres., Sls. Mgr.—Sylvia Evens

MICHIGAN

Acme Laminating & Plastics Co., Inc., Detroit (A)
Personnel: see p. 1179

Pace, F. D., Co., Grand Rapids (B)
Personnel: see p. 1169

MINNESOTA

Midland Coatings, Inc., Minneapolis (B)
Pres.—A. T. Leonard
Gen. Mgr., Sls. Mgr., Pur. Agt.—J. C. Hayes

NEBRASKA

Plectron Corp., Overton (B)

NEW JERSEY

Boonton Molding Co., Boonton (B)
Personnel: see p. 1170

Geneve Mfg. Co., Trenton (A, B)
Pres.—Eugene B. Greenspun
Vice Pres.—Maurice Greenspun

Hungerford Plastics Corp., Morristown (A)
Personnel: see p. 1170

Poinsettia Co., Inc., Pitman (B)
Pres.—C. O. Poincettia

NEW YORK

Atlas Plastics, Inc., Buffalo (B)

Axel Plastics Research Laboratories, Brooklyn (B)
Personnel: see p. 1172

Bricmar Mfg. Corp., New York (A, B)
Personnel: see p. 1172

Evers Industries, Inc., Long Island City (A)
Pres., Pur. Agt.—Kurt Evers
Vice Pres., Sales Mgr.—Geo. J. Werner

Frisch Doll Supply Co., Inc., New York (B)
Personnel: see p. 1172

Industrial Sales Engineers, New York (A, B)
Personnel: see p. 1173

International Plastic Co., New York (A, B)

Kramer, H. W., Co., Inc., Richmond Hill (B)
Pres.—Harry W. Kramer
Vice Pres.—Herbert L. Kramer
Sls. Mgr.—Chas. R. Kramer
Pur. Agt.—Justin Berber

W. & F., The, Mfg. Co., Inc., Buffalo (B)

OHIO

L & P Tool Co., Cincinnati (B)

Munray Products Div., The Fanner Mfg. Co., Cleveland (B)
Personnel: see p. 1175

Polykote, Inc., Cleveland (A, B)
Pres.—J. R. Jones
Vice Pres.—C. E. Hill
Pur. Agt.—E. Musselman

PENNSYLVANIA

Quelcor, Inc., Chester (A, B)
Pres.—Dr. J. Watson Pedlow
Sls. Mgr.—Merritt Wolfe
Pur. Agt.—Edwin L. Jones

WEST VIRGINIA

Plastics by . . . Hoover, Huntington (A)
Personnel: see p. 1177

WISCONSIN

Bostrom Corp., Milwaukee (B)
Personnel: see p. 1180

Lakeside Plastics Corp., Oshkosh (A, B)
Pres.—R. A. Nonweiler
Vice Pres. & Sls. Mgr.—A. P. Nonweiler
Pur. Agt.—V. Percey

Weber Plastics, Inc., Stevens Point (B)
Pres.—E. C. Wotruba
Vice Pres.—M. E. Sorensen
Sls. Mgr.—E. C. Wotruba, Jr.
Pur. Agt.—C. R. Cook

Film, Sheeting, and Coated Fabric Manufacturers

A. *Polyethylene Film—Plain*
B. *Polyethylene Film—Embossed or Printed*
C. *Polyethylene Sheet—Plain*
D. *Polyethylene Sheet — Embossed or Printed*
E. *Calendered Vinyl Film—Plain*
F. *Calendered Vinyl Film—Embossed or Printed*
G. *Cast Vinyl Film*
H. *Calendered Vinyl Sheeting—Plain*
I. *Calendered Vinyl Sheeting (Over 10 gage)—Embossed or Printed*
J. *Manufacturers of Vinyl-Coated Fabric Materials*

CALIFORNIA

Ellay Rubber Co., Los Angeles (E, F, H, I)
Pres.—DeWitt C. Maine
Vice Pres., Sls. Mgr.—Vincent L. Murphy
Vice Pres.—Warner Johnson
Pur. Agt.—E. P. Schreiner

Extruders, Inc., Hawthorne (A, B)
Personnel: see p. 1163

★ Indicates Advertiser

Flexfirm Products, S. El Monte (J)
General Mgr.—Dudley D. Eichorn
Chemist—Edwin M. Young
Sls. Mgr.—Alfred J. Michels
Pur. Agt.—James J. Goggin

Plastron Specialties, Inc., Los Angeles (A, C)
Personnel: see p. 1164

Santa Barbara Plastics, Sub. of Narmco Industries, Inc., Goleta (J)
Pres.—C. W. Brown
Vice Pres.—G. Havens
Gen. Mgr.—M. Scott Moulton
Prod. Mgr., Pur. Agt.—George C. Bilbe

COLORADO

Sawaya Manufacturing Co., Inc., Trinidad (A, B, C, D, I)
Personnel: see p. 1164

CONNECTICUT

Cordo Chemical Corp., Norwalk (J)
Exec. Vice Pres.—George H. Sherrard
Sls. Mgr.—F. M. Hall
Pur. Agt.—Robert Walsh

Ross & Roberts, Inc., Stratford (A, B, C, D, E, F, H, I, J)
Pres.—Arthur M. Ross, Jr.
Vice Pres., Sls. Mgr.—Alvin V. Roberts
Pur. Agt.—William Devine

DELAWARE

★du Pont de Nemours, E. I., & Co., Inc., Wilmington (J)

GEORGIA

Lamex, Inc., Norcross (A, C)
Pres.—W. R. McKelvy
Vice Pres.—M. J. McKelvy
Sls. Mgr.—A. P. Morley
Pur. Agt.—M. K. Hoffman

ILLINOIS

★Campco Div. of Chicago Molded Products Corp., Chicago (C)
Pres. & Gen. Mgr.—John J. Bachner
Vice Pres. & Div. Mgr.—Edward F. Bachner, Jr.
Sales Mgr.—James L. Bachner
Pur. Agt.—Frank Klingenmeier

Joanna Western Mills Co., Plastic Fabrics Div., Chicago (A, B, C, D, J)
Pres.—F. L. Regnery
Vice Pres.—Walter Regnery
Sls. Mgr. & Plastics Fabrics Dir.—J. P. Haughton
Pur. Agt.—Paul Pavlus

★Midwest Plastic Products Co., Chicago Heights (C)
Personnel: see p. 1166

Resincraft Plastics, Inc., Chicago (C)
Personnel: see p. 1166

Visking Co., Div. of Union Carbide Corp., Chicago (A)

MASSACHUSETTS

Bolta Products Div., The General Tire & Rubber Co., Lawrence (A, B, C, D, E, F, H, I, J)
Personnel: see p. 1167

Bortman Plastics Co., Boston (J)
Pres., Sls. Mgr.—Mark Bortman
Vice Pres.—J. B. Larus
Pur. Agt.—A. Fopiano

Goodall-Sanford, Inc., Reading (J)
Pres.—Walter E. Greer
Vice Pres.—Peter P. Shea
Sales Mgr.—Robert F. Daughters
Pur. Agt.—William E. Rock

Ludlow Papers, Inc., Plastics Div., Needham Heights (A)
Pres.—A. J. Thiel
Vice Pres.—R. S. Metzler
Pur. Agt.—George Bryant
Sls. Mgr.—W. F. Crimmin
Marketing Mgr.—J. J. Keville

Maynard Plastics, Inc., Salem (A, B)
Pres.—Ben Fanevil
Vice Pres.—Maynard Axelrod
Sales Mgr.—Manny Gassman
Sales Mgr.—Louis Miller

Novelty Bias Binding Co., Plastics Div., Chelsea (A, B)
Pres.—Ben Fanevil
Sls. Mgr.—Manny Gassman

Pyrotex Co., Inc., Leominster (J)
Pres.—M. C. Beren
Vice Pres., Sls. Mgr.—M. H. Etsten

★Sandman, Eli, Co., Worcester (J)
Pres.—Eli Sandman
Vice Pres., Sls. Mgr.—Edward A. Saxe
Pur. Agt.—Mrs. E. A. Riza

★ Indicates Advertiser

MICHIGAN

★Cadillac Plastic & Chemical Co., Detroit (A, C)
Personnel: see p. 1168

Lus-Trus Corp., Ypsilanti (C, D)
Personnel: see p. 1169

Woodall Industries, Inc., Detroit (C, D)
Personnel: see p. 1169

MINNESOTA

Minnesota Mining & Mfg. Co., Irvington Div., St. Paul (J)

MISSOURI

Bemis Bro. Bag Co., St. Louis (A, J)
Pres.—F. G. Bemis
Sales Dir., Vice Pres.—H. V. Howes
Exec. Vice Pres.—Judson Bemis

Dura-Lee Corp., Kansas City (B)
Pres., Sls. Mgr., L. E. Herzmark
Vice Pres., Pur. Agt.—E. E. Herzmark

NEW JERSEY

Carpenter, L. E., & Co., Wharton (J)
Pres.—George Lucas, Jr.
Exec. Vice Pres.—James V. Medici
Pur. Agt.—Arthur W. Mitchell

★Cooke Color & Chemical Co., Hackettstown (H)
Pres.—Frederick v. P. Cooke
Vice Pres.—Mrs. Edna M. Cooke
Pur. Agt.—Eugene Topoleski

★Davis, Joseph, Plastics Co., Kearney (A, C)
Personnel: see p. 1170

Efka Plastic Corp., Hoboken (B, D, F, I)
Pres.—William K. Friedman
Vice Pres.—George Katz
Sls. Mgr.—Alex Gottesman
Pur. Agt.—Alexander Katz

Federal Industries, Belleville (E, F, H, I, J)
Pres.—Louis M. Plansoen
Vice Pres., Sls. Mgr.—John W. F. Young
Pur. Agt.—Paul B. Grosjean

Fields, Charles S., Inc., Lodi (E, F, H, I, J)
Pres.—Charles S. Fields
Vice Pres.—Sidney Fields
Sls. Mgr.—Herbert Hammond
Pur. Agt.—Milton J. Chinich

Food Film, Inc., Caldwell Township (A)
Personnel: see p. 1170

★Gering Products, Inc., Kenilworth (A, B)
Pres.—Larry Gering
Exec. Vice Pres. & Sec.—Herman Gering
Vice Pres., Prod.—Ralph F. Hayes
Vice Pres., Eng.—Neil Koop
Sales Mgr., Molding Material Div.—Thomas I. O'Connor

Kaykor Industries, Inc., Yardville (J)
Pres.—I. Korn
Sls. Mgr.—J. L. Huscher

Plastic Horizons, Inc., Paterson (A, B)
Pres.—W. C. Leipold
Secy., Treas., Sls. Mgr.—Maurice Brown
Pur. Agt.—John Peyton

Plastic Laminating Corp., Vauxhall (E)
Personnel: see p. 1171

Poly Plastic Products, Inc., Paterson (A)
Personnel: see p. 1171

Polyplastex United, Inc., Union (J)
Personnel: see p. 1171

Polytex Corp., Hoboken (B, F)
Pres.—William K. Friedman
Vice Pres.—George Katz
Sls. Mgr.—Gerard Rothbart
Pur. Agt., Secy.—Alexander Katz

Reliance Plastic & Chemical Corp., Paterson (A, C)
Personnel: see p. 1171

Ridge Printing Co., Inc., Ridgefield (H, I, J)
Pres., Sls. Mgr.—George M. Cohan

NEW YORK

A.A.A. Plastic Co., New York (C)
Personnel: see p. 1172

Aacon Industries, Inc., Brooklyn (H, I)
Personnel: see p. 1172

American Combining Corp., Arverne (J)
Pres., Sls. Mgr., Pur. Agt.—J. T. Rudman

Associated Rubber & Plastic Corp., New York (E, F, H, I, J)
Pres.—Hyman Robbins
Vice Pres., Sales Mgr.—Ben Robbins
Pur. Agts.—Bernard Greenwald, Joseph Mauro

★Auburn Plastics, Inc., Auburn (C)
Personnel: see p. 1172

Blossom Manufacturing Co., Inc., Brooklyn (A, E, J)

Brulene Coated Textiles, Inc., Brooklyn (G, J)
Pres.—Morris J. Fassler
Vice Pres.—Newton J. Fassler
Sls. Mgr. and Pur. Agt.—H. Braverman

Chase Bag Co., New York (A, B)
Pres.—F. H. Ludington
Vice Pres., Plastics Div.—E. S. Elgin
Vice Pres., Gen. Sls. Mgr.—H. B. Rue
Pur. Agt.—J. R. Wible

Columbia Mills, Inc., The, Syracuse (J)
Pres.—Robert A. Harper
Vice Pres.—H. E. Wilkins
Pur. Agt.—G. Gozigian

Elm Coated Fabrics Co., Inc., New York (E, F, H, I, J)
Pres.—A. Mittman
Vice Pres.—E. Mittman
Sales Mgr.—M. H. Grant
Pur. Agt.—B. Gura

Fabric Leather Corp., New York (H, I, J)
Pres.—Samuel Schehr
Vice Pres., Sls. Mgr.—Louis Schehr
Pur. Agt.—Milton Schehr

Fassler, A. J., & Co., Inc., Brooklyn (G, J)
Pres.—M. J. Fassler
Vice Pres.—Newton J. Fassler
Sls. Mgr. & Pur. Agt.—Herman Braverman

Fersons Industries, Inc., New York (E, H)
Pres.—Harry L. Zuckerman
Vice Pres., Pur. Agt.—Louis Schehr
Sls. Mgr.—Milton Schehr

★Frank, J. P., & Co., Inc., Brooklyn (A, C)
Pres.—J. P. Frank
Vice Pres.—Henry Hilsenroth
Sls. Mgr.—Morton Frank
Pur. Agt.—John Fifat

Gordon-Lacey Chemical Products Co., Inc., Maspeth (E, F, H, I, J)
Pres. & Sales Mgr.—Robert Lacey
Vice Pres.—Robert Gordon
Pur. Agt.—Herman Lacey

Harte & Co., Inc., New York (A, B, C, D, E, F, H, I, J)
Pres.—Fred S. Strauss
Vice Pres.—Alan Shedlin, Fred S. Strauss, Donald Lipps, John Marzuli
Sls. Mgr.—Allan Shedlin
Pur. Agt.—Arthur Simon

Industrial Sales Engineers, New York (C)
Personnel: see p. 1173

Intraplast Mfg. Co., New York (B, D, F, I, J)
Vice Pres.—A. Perlman
Pur. Agt.—Robert Perlman

Jodee Plastics, Inc., Brooklyn (A, B, C, D)
Personnel: see p. 1173

Kordite Corp., Macedon (A, B)
Pres.—Howard Samuels
Vice Pres., Sales—William Dodenhoff
Pur. Agt.—James Murphy

Marbek, Inc., Brooklyn (F, I, J)
Pres.—Joseph S. Kaye
Vice Pres. & Sales Mgr.—Seymour Griss
Pur. Agt.—Hy Eleew

Metallic Plastics Corp., Long Island City (E, F, H, I)
Pres.—F. Z. Pearson

Micron Plastics Corp., Brooklyn (A)
Pres.—Theodore Arens
Vice Pres., Sales Mgr.—Marvin Krakow

Norman Plastics, Inc., New York (E, F, H, I, J)
Pres., Pur. Agt.—Norman S. Wile

Pearson Industries, Long Island City (E, F, H, I)
Pres.—F. Z. Pearson

★**Perforated Specialties Co.**, New York (A, B, C, D, E, F, G, H, I, J)
Pres. & Pur. Agt.—A. Sharkey
Vice Pres.—M. Weston
Sls. Mgr.—S. Sharkey

Plastic Film Co., Inc., New York (G, J)
Pres.—W. B. Nichols
Vice Pres.—A. C. Bunce
Sls. Mgr.—E. V. Disch
Pur. Agt.—G. Hagert

Presto Plastic Products Co., Inc., Brooklyn (B, D, E, F, H, I)
Pres.—J. P. Frank
Vice Pres.—H. Hilsenroth
Sls. Mgr.—M. Frank
Pur. Agt.—J. Pifal

Printon Corp., New York (A, B, C, D, E, F, G, H, I, J)
Pres.—Dr. Marc Goland
Vice Pres.—Lew B. Goland

Protective Lining Corp., Brooklyn (A, B, C, D, E, F)
Pres., Pur. Agt.—Jerome J. Dorfman
Sls. Mgr.—Louis Horowicz

Rand Rubber Co., Brooklyn (E, F, H, I, J)
Pres.—LeRoy H. Rand
Vice Pres.—E. M. French
Sls. Mgr.—E. A. Mason
Pur. Agt.—S. T. Lewis

★**Rubber Corp. of America**, Hicksville (E, F, H, I)
Pres.—W. A. Merton
Vice Pres.—R. G. Merton
Sls. Mgr.—A. W. Merton
Pur. Agt.—D. Martin

Rudd Plastic Fabrics Corp., Brooklyn (E, F, H, I)
Pres.—Albert Exelbert
Vice Pres., Pur. Agt.—Martin Exelbert
Sls. Mgr.—Michael Bey

Trans-Poly Corp., Mt. Vernon (C)
Pres., Pur. Agt.—Alfred Corman

★**Union Carbide Plastics Co., Div. of Union Carbide Corp.**, New York (E, G, H)

Velveray Corp., New York (B, E, F, H, I, J)
Pres.—Raymond L. Schwartz
Vice Pres.—Thomas Jordan
Sls. Mgr.—Sidney Rothbart
Pur. Agt.—C. Sanchez Sierle

Weblon, Inc., New York (J)
Pres.—S. L. Chambers
Vice Pres.—Robert F. Buehler
Vice Pres.—Robert Rose

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OHIO

American Agile Corp., Bedford (C)
Personnel: see p. 1174

Argo Plastic Products Co., Cleveland (C)
Personnel: see p. 1174

Canton Containers, Inc., Canton (A, B, C, D)
Personnel: see p. 1174

Clopay Corp., Cincinnati (A, B, C, D, G)
Pres.—John S. Stark
Vice Pres.—Arthur C. Greber
Sls. Mgr.—Henry P. Trounstine
Pur. Agt.—Philip Banta

Columbus Coated Fabrics Corp., Columbus (E, F, H, I, J)
Pres.—H. A. Flaharty
Vice Pres., Sls.—C. G. Jelliffe
Secy., Treas.—R. D. Altmaier
Pur. Agt.—S. N. McCloud

Conneaut Rubber & Plastics Co., Conneaut (C)
Personnel: see p. 1174

Dobeckmun Co., The, Div. of The Dow Chemical Co., Cleveland (A, B)
Pres.—T. F. Dolan
Vice Pres.—W. D. Sweeny
Sls. Mgr.—R. J. Jones
Pur. Agt.—J. Sullivan

Flex-O-Glass, Inc., Chicago (A, C)

Goodrich, B. F., Industrial Products Co., Marietta (A, E, F, H, I, J)
Pres.—C. O. DeLong
Gen. Mgr.—G. E. Field
Sls. Mgr.—M. L. Briscoe
Pur. Agt.—J. H. Ellis

Landers Corp., The, Toledo (J)
Pres.—John P. Howland
Vice Pres.—John C. Siegmann
Sls. Mgr.—C. M. Schols, Jr.
Pur. Agt.—L. F. McBride

Singleton & Mack, Inc., Akron (J)

Textileather Div., The General Tire & Rubber Co., Toledo (J)
Gen. Mgr.—J. D. Lippmann
Dir. of Sls.—J. S. Mather
Asst. to Dir. of Sls.—J. H. Schueddig
Pur. Agt.—C. A. Fuller

PENNSYLVANIA

Crystal-X Corp., Lenni Mills (A, B, C, D,)

Firestone Plastics Co., Pottstown (A, B, C, D, E, F, H, I)
Pres.—Roger S. Firestone
Vice Pres.—K. L. Edgar
Sls. Mgr.—C. F. Edelmann
Pur. Agt.—T. F. Storm

H & R Industries, Nazareth (A, C)

Masland Duraleather Co., Philadelphia (H, I, J)
Pres.—A. C. McCoy
Vice Pres., Sls.—J. A. Shadle
Vice Pres., Pur. Agt.—J. C. Lavin

★**Scranton Plastic Laminating Corp.**, Scranton (A, E, H)
Pres.—D. P. Keisling
Pur. Agt., Sec.-Treas.—C. W. Walter

RHODE ISLAND

Belon Chemical Co., Inc., Cranston (D)
Personnel: see p. 1176

Tupper Co., Woonsocket (C)
Personnel: see p. 1176

SOUTH DAKOTA

Raven Industries, Inc., Sioux Falls (A, B, E, F, G, J)
Pres.—C. J. Hoigaard
Sls. Mgr.—J. R. Smith
Pur. Agt.—Robert L. Brandsma

VIRGINIA

Electro Plastic Fabrics, Inc., Pulaski (J)
Pres.—Richard W. Beaver
Vice Pres.—James E. Lower

O'Sullivan Rubber Corp., Winchester (C, D, H, I)
Personnel: see p. 1177

WISCONSIN

Chippewa Plastics Co., Div. of Rexall Drug & Chemical Co., Chippewa Falls (A, C)
Personnel: see p. 1177

Presco Plastics, Milwaukee (E)
Personnel: see p. 1178

CANADA

Canadian General-Tower, Ltd., Ontario (E, F, H, I, J)
Pres.—Gordon Chaplin
Sales Mgr.—F. W. Graham
Pur. Agt.—Ernie Willis

Canadian Resins & Chemicals, Div. of Shawinigan Chemicals, Ltd., Montreal (A, B, C, D, E, F, G, H, I, J)
Pres.—H. S. Sutherland
Vice Pres., Gen. Mgr.—G. M. Hale
Sales Mgrs.—S. F. Brenegan, A. G. Pinard
Pur. Agt.—J. G. Giroux

ENGLAND

Commercial Plastics Ltd., London (A, B, C, D, E, F, H, I, J)
Managing Dir.—Dr. J. Pomeraniec

(For complete addresses, see Alphabetical Index, p. 1214)

Directory of Trade Designations of Plastic Materials and Processes

This list of trade designations is compiled for reference purposes from information supplied to us by the companies concerned. The descriptive information, however, is not guaranteed although, with a few exceptions, each of the trade designations was accompanied by a registration number and date. For complete addresses, refer to alphabetical list, page 1214.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
	A	
A-C	Polyethylene lubricant	Plastics & Coal Chemicals Div., Allied Chemical Corp.
A-C Polyethylene	Low-molecular-weight polyethylene	Semet-Solvay Petrochemical Div., Allied Chemical Corp.
A-M	Adhesives, resins, chemicals, etc.	American-Marietta Co., Adhesive, Resin & Chemical Div.
ASA	Anti-skinning agent	National Aniline Div., Allied Chemical Corp.
Aboglas	Laminated resin-impregnated asbestos and glass cloth	Natvar Corp.
Acco	Polymers, copolymers of acrylic and methacrylate esters	Acco Polymers
Accu-Cast	Fabricating of cavities and/or cores in any ferrous metal by the Shaw Process	Manco Products, Inc.
Accuratool	Capstan and second operation lathes	Dowding & Doll, Ltd.
Ace-Flex	Thermoplastic tubing and sheet	American Hard Rubber Co.
Ace-Hide	Rubber-plastic blend molding compound	American Hard Rubber Co.
Ace-Ite	Multi-polymer rubber and plastic molding compound	American Hard Rubber Co.
Ace Riji-Tuf	Resinous copolymer	American Hard Rubber Co., Div. Amerace Corp.
Ace Riviclor	Unplasticized polyvinyl chloride	American Hard Rubber Co.
Acetamine	Dyes	E. I. du Pont de Nemours & Co., Inc.
Acetaplex	Coatings for cellulose acetate	Sullivan Chemicals
Ace-Tempron	Heat-resistant rubber-plastic blend	American Hard Rubber Co., Div. Amerace Corp.
Ace-Tex	Black bituminous molding compound	American Hard Rubber Co.
Acrograve	Plastic engraving	The Acromark Co.
Acrojet	Automatic marking machines	The Acromark Co.
Acroleaf	Roll leaf foil and pigment	The Acromark Co.
Acromark	Marking and hot stamping machines	The Acromark Co.
Acronal	Polyacrylate	Badische Anilin- & Soda-Fabrik AG
Acrostamp	Metal stamps, dies and numbering machines	The Acromark Co.
Acrylast	Monofilaments from polyacrylonitrile-styrene	Dawbarn Bros., Inc.
Acrylicomb	Acrylic sheet facing to honeycomb	Plastex Laminates, Inc.
Acrylon	Rubber	The Borden Chemical Company
Adhesive 910	High-strength bonding adhesive based on a cyanoacrylate monomer	Eastman Chemical Products, Inc.
Adipol	Plasticizers-adipate esters	Ohio-Apex Div., F.M.C.
Adiprene	Casting and/or millable gum urethane elastomer; prepolymer	E. I. du Pont de Nemours & Co., Inc.
Advastab	Vinyl stabilizers	Advance Solvents & Chemical Div., Carlisle Chemical Works, Inc.
Advawax	Rubbery polybutenes for modifying agent	Advance Solvents & Chemical Div., Carlisle Chemical Works, Inc.
Advawet	Additive for reducing viscosity of plastisols	Advance Solvents & Chemical Div., Carlisle Chemical Works, Inc.
Aer-o-buoy	Closed-cell vinyl foam	Robinson Moulded Products, Ltd.
Aeroflex	Polyethylene extrusions	Anchor Plastics Co., Inc.
Aeron	Waterproof plastic-coated nylon fabrics (nylon & neoprene)	Flexfirm Products

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Agilide	Non-plasticized polyvinyl chloride semi-finished components	American Agile Corp.
Agiline	Polyethylene semi-finished components	American Agile Corp.
Air-Bond	Vinyl film and sheeting for pneumatic applications	Canadian Resins & Chemicals, Ltd.
Air-in-Oval	Acetylenic alcohols and glycols; alkyl-substituted acetylenes; aliphatic glycols; and furans and derivatives	Air Reduction Chemical Co.
Air-O-Flow	Process for thermoforming thermoplastic rigid and semi-rigid sheets	Air-O-Flow Industries, Inc.
Airborne	Urethane foam	Albert Trostel & Sons Co.
Airco in Design	Vinyl monomers; vinyl polymers; saturated aliphatic alcohols; ethylenic alcohols; and glycols	Air Reduction Chemical Co.
Aircomb	Impregnated kraft honeycomb	Douglas Aircraft Co., Inc.
Airmatic	Pneumatic valves and cylinders	Airmatic Valve, Inc.
Airoyal	Hydraulic and pneumatic cylinders and power units	The Airoyal Co.
Akroflex	C Rubber antioxidants	E. I. du Pont de Nemours & Co., Inc.
Alamask	Odor control chemicals	Rhodia, Inc.
Alathon	Polyethylene resin	E. I. du Pont de Nemours & Co., Inc.
Albone	Hydrogen peroxide	E. I. du Pont de Nemours & Co., Inc.
Alcylite	Phenolic resins and molding powders	Alcylite Plastics & Chemical Corp.
Aldarome	Odorants for formaldehyde	Fritzsche Brothers, Inc.
Alfane	Epoxy-based cement	The Atlas Mineral Products Co.
Alipal	Surface active agent; antistatic agent	Antara Chemicals, Div. of General Aniline & Film Corp.
Alkanex	Polyester coating materials	General Electric Co.
Alkanol	B Surface active agents and textile processing agents	E. I. du Pont de Nemours & Co., Inc.
Alk-O-Flex	Plasticizers for polyvinyl copolymers	Alkydol Laboratories, Inc.
Alk-O-Mer	Polymer and copolymer dispersions	Alkydol Laboratories, Inc.
Alkor	Furan resin cement	The Atlas Mineral Products Co.
Allfoam	Polyester and polyether foam	Robinson Foams, Ltd.
Alnor	Pyrometers, controllers, thermocouplers	Illinois Testing Laboratories, Inc.
Alperox C	Technical lauroyl peroxide	Wallace & Tiernan, Inc.
Alpex	Hydrocarbon resins	Alkydol Laboratories, Inc.
Alpha	Extruded plastic pipe and tubing	Alpha Plastics, Inc.
Alsibronx	Ground mica	Franklin Mineral Products Co.
Alundum	Abrasives and grinding wheels	Norton Co.
Amberlite	Ion exchange resin	Rohm & Haas Co.
Amcol	Semi-automatic rotary milling machines	Dowding & Doll, Ltd.
Ameran	Liquid dispersions of plastic materials	B. F. Goodrich Co.
Amercoat	Protective coatings	Amercoat Corp.
Amester	Polyester resins	American Alkyd Industries
Ampacet	Thermoplastic molding compounds	American Molding Powder & Chemical Corp.
Ampcoflex	Rigid plastic structures	Atlas Mineral Products Co.
Amphesive	Series of adhesives for industrial use	The Atlas Mineral Products Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Ampreg	Polyester resin coating	The Atlas Mineral Products Co.
Amres	Phenolic, resorcinol, urea resins	American Marietta Co., Resin & Chemical Div.
Analyte	Color comparator	Crown Engineerng & Sales Co.
Ancorene	High-impact styrene extrusions	Anchor Plastics Co., Inc.
Anesite	Extruded thermoplastic products, including pipe and tubing	Anesite Co.
Ansol	Denture alcohol solvent	U. S. Industrial Chemicals Co.
Anstac	Anti-static agents and solutions for vinyl, styrene	Chemical Development Corp.
Anstal C	Anti-static agents	Chemical Development Corp.
Antarox	Surface active agent; dispersant in cellophane manufacturing	Antara Chemicals, Div. of General Aniline & Film Corp.
Antioxidant B and Antioxidant D	Anti-skinning agents	Allied Chemical Corp.
Anti-static Compound #79	Destaticizers for vinyls, styrenes, acrylic, etc.	Merix Chemical Co.
Anti-static Compound #79-OL	Destaticizer for synthetic and plastic yarns	Merix Chemical Co.
Anti-Sun	Wax for use in rubber to improve its resistance to sun cracking	Cary Chemicals, Inc.
Antox	Rubber antioxidants	E. I. du Pont de Nemours & Co., Inc.
Aquablak	Carbon black dispersed in water	Columbian Carbon Co.
Aqua-Flakes	Cold water-soluble adhesives	National Starch Co.
Aquarex	Surface active agent and mold lubricant	E. I. du Pont de Nemours & Co., Inc.
Arabol	Adhesives	The Arabol Mfg. Co.
Araldite	Epoxy resins	Ciba Co., Inc.
Arcturus	Colorants (Red)	Sherwin Williams Co.
Argo	Prefix for fabricated products based on polyethylene and polypropylene	Argo Plastic Products Co.
Aritemp	Epoxy resin	Aries Laboratories, Inc.
Armalon	TFE-fluorocarbon resin-coated glass fabrics, tapes and laminates	E. I. du Pont de Nemours & Co., Inc.
Armorex	Special high-strength fibrous glass reinforced polyester laminates	The Englander Co., Inc.
Armorhide	Textured plastic finish, resembling leather	John L. Armitage & Co.
Armor-Kut	Chemical grinding aid	Armour & Co., Coated Abrasives Div.
Armour-Clad	Coated abrasives	Armour & Co., Coated Abrasives Div.
Arnar	Vinyl and polyethylene film and sheeting	Ross & Roberts, Inc.
Asmidar	Hand-operated injection molding machines	British Machines & Foundry Supplies, Ltd.
Asp	Mineral filler	Minerals & Chemicals Corp. of America
Astralon	Vinyl chloride polymer	Dynamit-Actien-Gesellschaft
Atlac	Polyester resin	Atlas Powder Co.
Atlas	Pigments and dyes	H. Kohnstamm & Co., Inc.
Audigage	Ultrasonic thickness testers	Branson Instruments, Inc.
Avisco	Urea-formaldehyde compounds	American Viscose Corp.
Avitex	Antistatic developer, softener, and surface active agents	E. I. du Pont de Nemours & Co., Inc.
Azosol	Spirit-soluble dyes used in surface coloring of plastics	General Dyestuff Co., Div. of General Aniline & Film Corp.

B

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
B-Preg	Glass fabrics, mats, and papers preimpregnated with epoxy, polyester, silicone, and phenolic resins	Polyplastex United, Inc.
BRC, BRH, BRS, BRT, BRV	Hydrocarbon plasticizers and extenders	Plastics & Coal Chemical Div., Allied Chemical Corp.
BZO 50	50% benzoyl peroxide paste in tricresyl phosphate	U. S. Peroxygen Corp.
Bakelite	Vinyl ethyl ether; vinyl acetate latices; molding compounds; molding powders; resins of many types (see listings for Union Carbide Plastics Co. in Resins, Molding Compounds and Other Basic Materials Section); resin emulsions; water soluble resins; vinyl organosols and vinyl plastisols; styrene copolymers	Union Carbide Plastics Co., Div. of Union Carbide Corp.
Banbury	Mixers	Farrel-Birmingham Co., Inc.
Barak	Accelerator activator	E. I. du Pont de Nemours Co., Inc.
Barca	Barium-cadmium stabilizers	Deecy Products Co.
Bardol	Hydrocarbon processing agent and plasticizer	Plastics & Coal Chemicals Div., Allied Chemical Corp.
Barinac	Heat stabilizer for vinyl	National Lead Co.
Bar-ox	Alkyd base protective iron and steel paint	Truscon Laboratories
Bartalon	Asphalt and fiber moldings	Plymouth Industrial Products, Inc.
Baytex	Natural & GRS latex adhesion and coatings	UBS Chemical Corp.
Beau-Myte	High-pressure laminated plastic surfaced material	The BoMyte Co.
Beckacite	Maleic, fumaric, and modified phenolic resins	Reichhold Chemicals, Inc.
Beckamine	Alcohol-soluble urea-formaldehyde resins	Reichhold Chemicals, Inc.
Beckolin	Synthetic oils	Reichhold Chemicals, Inc.
Beckopol	High melt point modified phenolic resins	Reichhold Chemicals, Inc.
Beckosol	Alkyd resins	Reichhold Chemicals, Inc.
Beetle	Urea-formaldehyde molding material	American Cyanamid Co.
Belcobalsa	Core material for sandwich structures	Balsa Ecuador Lumber Corp.
Benvic	Vinyl chloride and vinyl acetate chloride compounds	S. A. Solvic
Bexan	PVC monofilaments	B.X. Plastics, Ltd.
Bexoid	Cellulose acetate	B.X. Plastics, Ltd.
Bextrene	Polystyrene and acetate	B.X. Plastics, Ltd.
Bipel	Line of compression and transfer molding presses, pneumatic accumulators, hydraulic power units, preformers, etc.	B. I. P. Engineering Ltd.
Blacar	Vinyl chloride resin; vinyl compound	Cary Chemicals, Inc.
Black-Buty	Pipe and pipe fittings	Anesite Co.
Black Pearls	Pelleted channel carbon blacks	Godfrey L. Cabot, Inc.
Black-Poly	Polyethylene pipe and fittings	Anesite Co.
Black Shield	Pigment dispersions	Carbon Dispersions, Inc.
Blend-eze	Wetting agent	Gering Products, Inc.
Bold	Daylight fluorescent silk screen products	Lawter Chemicals, Inc.
Boltaflex	Supported and unsupported flexible vinyl sheeting	Bolta Co., Inc.,
Bolta-Quilt	Quilted plastic films	Bolta Co., Inc.,
Boltaron	Styrene copolymer (A-B-S) sheet and vinyl sheet	Bolta Co., Inc.,
Bomb-Lube	Mold release	Price-Driscoll Corp.
Bonar	Plastic boning	Anchor Plastics Co., Inc.
Bond	Adhesives	Bond Adhesives Co.
Bondmaster	Industrial adhesives	Rubber & Asbestos Corp.
Bondrite	Natural rubber solvent cements	UBS Chemical Corp.
Bondstrand	Fibrous glass reinforced epoxy pipe	Amercoat Corp.
Bondzall	Polyester filler, solder	Schramm Fiberglass Products, Inc.
Bontex	Shade cloth, plastic-coated	Columbus Coated Fabrics Corp.
Bosfilm	Vinyl plastic in sheet form, coated with adhesive	B. B. Chemical Co.
Bostik	Adhesive	United Shoe Machinery Co.
Breeth-ees	Sheeting-vinyl supported and unsupported	Rand Rubber Co.
"Brighten" Leaf	Roll leaf and roll leaf equipment	Griffin, Campbell, Hayes, Walsh, Inc.
Broncho	Composition supported vinyl	Textileather Div., The General Tire & Rubber Co.
Brushmaster	Brush setting compounds and paint roller adhesives	Rubber & Asbestos Corp.
Busada	Plastics pipe and tubing	Busada Mfg. Corp.
Butacite	Polyvinyl butyral resin	E. I. du Pont de Nemours & Co., Inc.
Butakon	Butadiene - acrylonitrile copolymers; butadiene-styrene copolymers	Imperial Chemical Industries, Inc.
Butaplex	Coatings for butyrate	Sullivan Chemicals
Butaprene	Composition of synthetic rubber or rubber-like materials	Firestone Plastics Co.
Butvar	Polyvinyl butyral resins	Shawinigan Resins Corp.

C

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
C. D.	Lubricants, adhesives, coatings, etc.	Chemical Development Corp.
CO	Acrylic sheet	Cast Optics Corp.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
CR-39	Allyl ester sheets	Cast Optics Corp.
Cab-O-Sil	Colloidal silica-thickening, thixotropic, gelling, suspension, flatting, reinforcing agents	Godfrey L. Cabot, Inc.
Cadco	Extruded acrylic; hi-impact styrene sheets; cast acrylic tubing; rods; polyester resin; adhesives; other stock forms and shapes; anti-static polishes; etc.	Cadillac Plastic & Chemical Co.
Cadox	Organic peroxide catalysts	Cadet Chemical Corp.
Calcerite	Amino-resin casting compound	Furnace Plastics, Inc.
Calvinac	Vinyl-based air-dry coatings	James Lithgow Co., Inc.
Calwhite	Natural calcium carbonate extender	The Calcium Products Div., The Georgia Marble Co.
Camel-Carb	Dry ground calcium carbonate filler	Campbell Sons Corp., Harry T.
Camel-Tex & Camel-Wite	Water ground calcium carbonate filler	Campbell Sons Corp., Harry T.
Campco	Thermoplastic sheet and film	Campco Div., Chicago Molded Products Corp.
Canvalope	Plastic coated paper for bags	Kehr Products Co.
Capracyl	Dyes	E. I. du Pont de Nemours & Co., Inc.
Carbasol	Modified rosin esters	C. J. Osborn Co.
Carbium	Precipitated calcium carbonate, average particle sizes	Diamond Alkali Co.
Carbolac	High color channel carbon blacks	Godfrey L. Cabot, Inc.
Carbowax	Polyethylene glycols	Union Carbide Chemicals Co.
Carlon	Plastic pipe	Carlon Products Corp.
Carter Disc Separator	Machine for sizing or separating materials such as plastic tubes	Hart-Carter Co.
Cascamite	Powdered synthetic resin adhesives	The Borden Chemical Co.
Casco	Line of glues and adhesives (e.g. Cascola label glue; Cascophen; Cascorez; etc.)	The Borden Chemical Co.
Cascolac	Aqueous casein coating solutions	The Borden Chemical Co.
Cascote	Synthetic resin	The Borden Chemical Co.
Catalin	Styrene, polyethylene, and nylon molding compounds; urea, phenolic, cresylic, resorcinol, melamine, acrylic, and styrene resins for bonding, impregnating, laminating, and gluing; etc.	Catalin Corp. of America
Celanese	Acetate film, sheeting, molding material; polyethylene film, sheeting, rigid sheeting; polyester resins; polyvinyl acetate emulsions	Celanese Corp. of America, Plastics Div.
Celanthrene	Dyes	E. I. du Pont de Nemours & Co., Inc.
Celite	Diatomite products, filter aids, and mineral filters	Johns-Manville
Cellon	Cellulose acetate with plasticizers	Dynamit-Actien - Gesellschaft
Cellophan	Cellulose film	Kalle & Co. A. G.
Cellosize	Hydroxyethyl cellulose	Union Carbide Chemicals Co.
Celogen	Chemical blowing agent for plastics and rubber	Naugatuck Chemical Div., U. S. Rubber Co.
Celoron	Molded macerated plastic	Continental - Diamond Fibre, Div. of the Budd Co., Inc.
Century Brand	Fatty acids	Harchem Div., Wallace & Tiernan, Inc.
Certus	Vinyl resin adhesives	Monite Waterproof Glue Co.
Chemclad	Vinyl insulation	Carolina Industrial Plastics Div., Essex Wire Corp.
Chemelec	Teflon with additives	United States Gasket Co., Plastics Div., Garlock Packing Co.
Chemfast	Epoxy resin, chemically resistant paint	Truscon Laboratories
Chemigum & Chemigum latices	Butadiene/acrylonitrile rubber and latices	The Goodyear Tire & Rubber Co.
Chemigum SL	Millable gum prepolymer; urethane elastomer	The Goodyear Tire & Rubber Co.
Chemiseal	Plastic film; fluorocarbons; rods and tubes; nylons; rigid sheets	U.S. Gasket Co., Plastics Div., Garlock Packing Co.
Chemlon	Fabricated Teflon products	Crane Packing Co.
Chem-O-Glas	Reinforced plastic building panels	Chemold Co.
Chem-O-Sol	Vinyl plastisols for molding, coating, etc.	Chemical Products Corp.
Chempounds	Barrel finishing compounds	Techline Div., Wheelabrator Corp.
Chemrok	Chemically resistant plastic for electroplating apparatus	The Richardson Co.
Chilton Process	Mechanical inlaying of metal; metallizing rigid sheets or shapes	Plastic Inlays, Inc.
Chlorowax	Chlorinated paraffin wax; liquid and resinous grades	Diamond Alkali Co.
Chromacyl	Dyes	E. I. du Pont de Nemours & Co., Inc.
Chromcote	Chrome-colored vacuum metalized finish	The Eyelet Specialty Co.
Chromalox	Electric meating equipment	Edwin L. Wiegand Co.
Chromar	Metallized polyester film	Hastings & Co., Inc.
Clam Shell Molding	Process of molded thermoplastic hollow parts produced by methods other than conventional blow molding	Woodall Industries, Inc.
Clarite	Heat and light stabilizer for vinyl	National Lead Co.
Claw-Tooth	Positive angle saw tooth blade	The DoAll Co.
Clepco	Radiant heaters; immersion heaters	Cleveland Process Co.
Clevelon	Asphalt and fiber moldings	Plymouth Industrial Products, Inc.
Clopane	Clear vinyl film	Clopay Corp.
Cobex	Rigid vinyl copolymer	B. X. Plastics Ltd.
Coblac	Carbon black dispersions	Columbian Carbon Co.
Coethloblak	Carbon black dispersions	Columbian Carbon Co.
Colfoam	Urea formaldehyde spheres for foams, etc.	Colton Chemical Co.
Collacral	Thixothropic agent for dispersions and for the production of specialty adhesives	Badische Anilin- & Soda-Fabrik AG
Col-o-vin & Col-o-foam	Unsupported plastic sheet laminated to polyurethane foam	Columbus Coated Fabrics Corp.
Col-o-tex	Pyroxylin coated fabric	Columbus Coated Fabrics Corp.
Col-o-vin & Col-o-hyde	Vinyl coated fabric and unsupported sheet and film.	Columbus Coated Fabrics Corp.
Columbia	Activated carbon used for solvent recovery	Union Carbide Olefins Co., Div. of Union Carbide Corp.
Comblite	Skylight of honeycomb	Plastex Laminates, Inc.
Conncord	Plastic-coated rope	Jessall Plastics Div., Electric Storage Battery Co.
Conoco	Secondary plasticizer for PVC resin formulations	Continental Oil Co., Inc.
Conolite	Polyester resins and laminates	Flexible Packaging Div., Continental Can. Co. Inc.
Conolon	Preimpregnated laminating materials	Narmco Resins & Coatings Co.
Continental	Carbon black	Witco Chemical Co.
Continex	Carbon black	Witco Chemical Co.
Contour-Matic	Variable band sawing machines	DoAll Co., The
Cordfil	Random cut cotton, rayon, or nylon cord	The Rayon Processing Co. of Rhode Island
Cordo	Lacquer coatings for bonding, lacquer coatings for plastic sheeting	Cordo Chemical Corp.
Cordobond	Special purpose adhesives	Cordo Chemical Corp.
Cordoflex	Protective coatings	Cordo Chemical Corp.
Cordoglas	Plastic resins & compounds for impregnating	Cordo Chemical Corp.
Cordopreg	Preimpregnated fibrous glass fabrics	Cordo Molding Products, Inc.
CoRes Co	Corrosion resistant coatings	Cordo Chemical Corp.
Coresinblak	Carbon black dispersions	Columbian Carbon Co.
Corobex	Bacteriostatic and fungistatic compounds	Bex Industries, Inc.
Corovit	Cold setting core binders	Reichhold Chemicals, Inc.
Corpolin	Industrial humectant or paper plasticizer	Heyden Newport Chemical Corp.
Corvel	Fusion bond finishes	Polymer Corp.
Cosmolite	Phenol-formaldehyde resin	Colton Chemical Co.
Cosme-chrome	Applique-process for plastic film	Cosmos Electronic Machine Corp.
Cosmos	Electronic sealing machines	Cosmos Electronic Machine Corp.
Cosol	Hydrocarbon solvent	Neville Chemical Co.
Costyreneblak	Carbon black	Columbian Carbon Co.
Coverlac	Solvent type protective coating compounds	Spraylat Corp.
Covinylblak	Carbon black	Columbian Carbon Co.
Cowaxblak	Carbon black	Columbian Carbon Co.
Cresline	Plastic pipe	Crescent Plastics, Inc.
Crest-Foam	Vinyl foam	Crest Chemical Industries Corp.
Crodon	Industrial electroplating of hard chromium, copper nickel, tin, silver, etc.; on machinery (e.g. embossing rolls, molds, etc.)	Chromium Corp. of America
Cronaflex	Engineering reproduction film	E. I. du Pont de Nemours & Co., Inc.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Cross Tensilite	Multi-directionally stretched films	Multi-Stretched Films, Inc.
Cryptone	Zinc sulphide pigments	The New Jersey Zinc Co.
Crystal clear	Press polished vinyl	Jacobson Mfg. Co.
Crystal Seal	Back decorated molded styrene or acrylic	Gits Molding Corp.
Crystolon	Abrasive grinding wheels, refractories	Norton Co.
Cub-line & Cub-printer	Flexographic printing presses	Wolverine Paper Converting Machine Corp.
Cumar	Resin	Plastics & Coal Chemicals Div., Allied Chemical Corp.
Cyclomatik	Portable straight knife cutting machine for plastics	H. Maimin Co., Inc.
Cyclon	Portable round knife cutting machine for plastics	H. Maimin Co., Inc.
Cycolac	Acrylonitrile-butadiene-styrene copolymer	Marbon Chemical Div. Borg-Warner Corp.
Cymel	Melamine molding compounds, adhesive, and laminating resins	American Cyanamid Co., Plastics and Resins Div.
Cyzac	Laminating resins	American Cyanamid Co.

D

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
D.C.	Vinyl cloth coated on both sides	S. I. Jacobson Mfg. Co.
DG "70"	Colorant with light transmission for polystyrenes	Sheffield Plastics, Inc.
DLP	Monofilaments, multifilaments, ribbon yarns, etc., from linear polyolefins	Dawbarn Bros., Inc.
DPR	Natural depolymerized rubber	H. V. Hardman Co., Inc.
DS-207	Stabilizer lubricant for vinyl chloride	National Lead Co.
Dacron	Polyester fiber	E. I. du Pont de Nemours & Co., Inc.
Dake	Presses	Dake Corp.
Dapon	Homopolymer of diallyl phthalate	FMC Organic Chemicals Div., Food Machinery & Chemical Corp.
Darex	Plasticizer; polyvinyl acetate emulsion; high styrene copolymer latex; high styrene copolymer resin	Dewey and Almy Chemical Co., Div. of W. R. Grace & Co.
Darvis	Rigid PVC sheet	Imperial Chemical Industries, Ltd.
Davenite	Water ground mica filler	Hayden Mica Co., Inc.
Davis-Standard	Thermoplastic and rubber extruding machine and accessories	Davis-Standard, Div. of Franklin Research Corp.
Daxad	Dispersing agents	Dewey and Almy Chemical Co., Div. of W. R. Grace & Co.
Daycollan	Cast urethane elastomer	Dayton Rubber Co.
Daycor	Corrugated and flat sheet for non-structural uses	Strick Plastics Co.
Decalin	Solvent	E. I. du Pont de Nemours & Co., Inc.
Decarlite	Decorative high-pressure laminate	Decar Plastic Corp.
Decradall	Decorative, formable polyester rigid sheet	Woodall Industries, Inc.
Dekoron	Plastic extrusions	Samuel Moore & Co.
Delrin	Acetal resin	E. I. du Pont de Nemours & Co., Inc.
Denflex	Vinyl plastisols and primers	Dennis Chemical Co.
Den-Nex	Hand cleaning compound	Dennis Chemical Co.
Densite	Gypsum cement	Bestwall Certain-Teed Sales Corp.
Design Lustrelite	High luster patterned acrylic sheets and button blanks	U. S. Plastic Products Corp.
Devcon	Metallic-plastic compounds for making molds	Chemical Development Corp.
Devine	Vacuum chamber dryers; conical blenders; double ribbon mixers	J. P. Devine Mfg. Co.
Dexstar	Long fibre specialty papers	C. H. Dexter & Sons, Inc.
Diagen	Dyes	E. I. du Pont de Nemours & Co., Inc.
Diakon	Acrylic molding powder	Imperial Chemical Industries, Ltd.
Diall	Diallyl phthalate molding compounds	Mesa Plastics Co.
Diamond	Vulcanized fibre	Continental-Diamond Fibre Corp.
Diamond	Polyvinyl chloride resins; copolymer resins	Diamond Alkali Co.
Diatol	Denatured alcohol solvent	U. S. Industrial Chemicals Co., Div. of National Distillers and Chemical Corp.
Dilecto	Laminated phenolic	Continental-Diamond Fibre Corp.
Dimetcote	Protective coating	Amercoat Corp.
Die-Part Portelvator	Portable elevating table	The Hamilton Tool Co.
Diofan	Polyvinylidene chloride emulsion	Badische Anilin- & Soda-Fabrik AG
Diorid	Polyvinylidene chloride for filaments	Heyden Newport Chemical Corp.
Dipentek	Dipentaerythritol technical	Heyden Newport Chemical Corp.
Disogrin	Cast urethane elastomer	Disogrin Industries, Inc.
Dispersite	Aqueous dispersions of rubber	U.S. Rubber Co.
Domepak	Blister packages	Plastic Artisans, Inc.
Doray	Metalized Mylar films and laminates	The Dorrie Process Co., Inc.
Dorlon	Fabricated Teflon and thermoplastic products	John L. Doré Co.
Dorn	Vinyl film and sheeting and coated fabrics	Gordon-Lacey Chemical Products Co., Inc.
Doven	Slitting, cutting machines; sheeting equipment; rewinders; auto. tension unwinders	Appleton Machine Co., Doven Div.
Dow Corning	Silicones	Dow Corning Corp.
Dowding	Automatic injection molding machines	Dowding & Doll, Ltd.
Draco	Plastic shears	L. E. Birbach Associates, Inc., Draco Div.
Drapex	Plasticizers	Argus Chemical Corp.
Dritherm	Infra-red drying equipment	North American Electric Lamp Co.
Drycol	Pigments for coloring plastics	Gering Products, Inc.
Dry-Flo	Free-flowing dusting powder	National Starch Products, Inc.
Dryply	Preimpregnated polyester-fibrous glass cloth and mat	Flexfirm Products
Duco	Enamels, finishes, lacquer sealers	E. I. du Pont de Nemours & Co., Inc.
Dulux	Enamels, finishes, paints, varnishes, and foam resin	E. I. du Pont de Nemours & Co., Inc.
Duol	Pigments	E. I. du Pont de Nemours & Co., Inc.
Duponol	Sodium lauryl sulfate and surface active agents	E. I. du Pont de Nemours & Co., Inc.
DuRaFoam	Prefoamed epoxy blocks	D & R Pilot Plants, Inc.
Duralon	Furane Resins	U. S. Stoneware Co.
Duran	Vinyl upholstery	Masland Duraleather Co., The
Duratex	Supported vinyl fabric	Textileather Div., General Tire & Rubber Co.
Durethene	Polyethylene thin-wall tubing and sheeting	Koppers Co., Inc.
Durex	Pipe and fittings	Franklin Plastics, Inc.
Durez	Phenolic, polyester, and diallyl phthalate molding compounds; phenolic resins	Durez Plastics Div., Hooker Chemical Corp.
Durite	Synthetic resins	The Borden Chemical Co.
Duxkin	Vinyl film and sheeting	Harte & Co., Inc.
Dyal	Alkyd and styrenated alkyd resins for coatings	The Sherwin-Williams Co.
Dyfoam	Foam plastic insulation	Dyfoam Corp.
Dylan	Polyethylene	Koppers Co., Inc.
Dylene	Polystyrene	Koppers Co., Inc.
Dylite	Expandable polystyrene	Koppers Co., Inc.
Dymal	Maleic resins for coatings	The Sherwin-Williams Co.
Dynatherm	Dielectric heating equipment	Guild Electronics, Inc.
Dynel	Synthetic fibers	Union Carbide Chemicals Co., Div. of Union Carbide Corp.
Dyphene	Phenol formaldehyde resins for coatings	The Sherwin-Williams Co.
Dyphenite	Phenol formaldehyde modified resins for coatings	The Sherwin-Williams Co.
Dyphos	Heat, light, and outdoor weathering stabilizer for vinyl chloride	National Lead Co.
Dypol	Polyester resins	The Sherwin-Williams Co.
Dythal	General-purpose heat and and light stabilizer for vinyl chloride	National Lead Co.
Dytron	Laminated fabric	Dynamit-Actien-Gesellschaft

E

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Easton	Rigid pipe and tubing	Mannesmann-Easton Plastic Products Co., Inc.
Eccobild	Tooling resins	Emerson & Cuming, Inc.
Eccobond	Adhesives	Emerson & Cuming, Inc.
Eccocoat	Surface coatings	Emerson & Cuming, Inc.
Eccofoam	Foam products	Emerson & Cuming, Inc.
Eccomold	Laminating resins	Emerson & Cuming, Inc.
Eccoseal	Impregnants	Emerson & Cuming, Inc.
Eccosorb	Absorbers	Emerson & Cuming, Inc.
Elastacast	Cast urethane elastomer	Acushnet Process Co.
Elastex	Plasticizer	Plastics & Coal Chemicals Div., Allied Chemical Corp.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Elastofoam	Vinyl plastisol compounds	Elastomer Chemical Corp., Div. of Union Carbide Plastics Co.
Elastolex	Elastic fabric supported vinyl	Textileather Div., The General Tire & Rubber Co.
Eldo	Methyl esters and fatty acids	Foremost Food & Chemical Co.
Eldoplast	Plasticizer	Foremost Food & Chemical Co.
Electroglas	Cast transparent copolymer sheet	Glasflex, Inc.
Electronheat	Dielectric preheating generators	Resdel Engineering Corp.
Elf	Medium color channel carbon blacks	Godfrey L. Cabot, Inc.
Elftex	Oil furnace carbon blacks	Godfrey L. Cabot, Inc.
Elmer's	Adhesives	The Borden Chemical Co.
Elmes	Hydraulic presses and equipment	Elmes Engineering Div., American Steel Foundries
Elprene	Rubber-base coating	Atlas Mineral Products Co.
Elvacet	Polyvinyl acetate emulsion	E. I. du Pont de Nemours & Co., Inc.
Elvanol	Polyvinyl alcohol	E. I. du Pont de Nemours & Co., Inc.
Emerox	Dibasic acid	Emery Industries, Inc.
Emersol	Stearic and oleic acids	Emery Industries, Inc.
Emery	Fatty acids and oleic esters	Emery Industries, Inc.
Emfac	Monobasic acids	Emery Industries, Inc.
Emhart	Vacuum forming machines	Emhart Mfg. Co., Standard-Knapp Div.
Empol	Dimer acids	Emery Industries, Inc.
Emulphor	Surfactant; emulsifying agent; latex stabilizer; antistatic agent	Antara Chemicals, Div. of General Aniline & Film Corp.
Emu-Pulver 120 FD	Styrene-containing mixed polymers for the production of aqueous dispersions for paints	Badische Anilin- & Soda-Fabrik AG
Endor	Rubber peptizing agent	E. I. du Pont de Nemours & Co., Inc.
Endura	Impregnated and coated papers	Endura Corp.
Engravograph	Portable and bench type engraving machines	New Hermes Engraving Machine Corp.
Ensolex	Cellular plastic material in sheet form or extruded shapes	United States Rubber Co.
Ensolite	Cellular vinyl in sheet form and extruded shapes	United States Rubber Co.
Epibond	Synthetic resins for use in adhesives	Furane Plastics, Inc.
Epilote	Epoxy resin	Shell Chemical Corp.
Epiphen	Epoxide resins	The Borden Chemical Co.
Epi-Rez	Epoxy resins	Jones-Dabney Co.
Epi-Tex & Epi-Var	Epoxy ester resins	Jones-Dabney Co.
Epocap	Epoxy casting and coating compounds	H. V. Hardman Co., Inc.
Epocast	Casting, bonding, and laminating resins	Furane Plastics, Inc.
Epolene	Low - melt polyethylene for casting and slush molding	Eastman Chemical Products, Inc.
Epo Lux-100	Air drying, chemically cured anti - corrosive coating	Steelcote Mfg. Co.
Epon	Epoxy resin for coatings, potting, laminating, adhesives, and tool and die fabrications	Shell Chemical Corp.
Epon Curing Agent	Hardeners for epoxy resin systems	Shell Chemical Corp.
Eponite	Resin for textile finishing	Shell Chemical Corp.
Eposet	Epoxy setting compounds	H. V. Hardman Co., Inc.
Epotuf	Epoxy resins	Reichhold Chemicals, Inc.
Epoxical	Resins for tooling and adhesives	U.S. Gypsum Co.
Epoxylite	Epoxy resin formulations	The Epoxylite Corp.
Erdco	Blister sealing machines	Erdco Engineering Corp.
Estafoam	Unsaturated polyester, thermoset, and rigid foam plastic	Vanguard Products, Inc.
Estane	Casting and/or millable gum urethane elastomer; prepolymer	B. F. Goodrich Co.
Estynox	Epoxy or acetoxy fatty ester plasticizers	The Baker Castor Oil Co.
Ethocel	Ethyl cellulose	Dow Chemical Co., The
Ethylac	Vulcanizing agent	Pennsylvania Salt Manufacturing Co.
Evenglo	Polystyrene	Koppers Co., Inc.
Everflex	Vinyl acetate copolymer emulsion	Dewey and Almy Chemical Co., Div. of W. R. Grace & Co.
Everlite	Reinforced polyester fibrous glass—flat and corrugated	Everlite Corp.
Everwhite	Light stable polystyrene	Sheffield Plastics, Inc.
Evr-Kleer	Cast acrylic sheets	Cast Optics Corp.
Exact Weight	Scales — industrial and commercial	Exact Weight Scale Co.
Excelsior	Carbon black	Columbian Carbon Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Exon	Raw or partly prepared plastic resins in the form of powders, granules, pellets, plastisols, or latices	Firestone Plastics Co.
Extrudalite	Extruded sheets	Rotuba Extruders, Inc.
Extrudo-Film	Wraps, films, sheets, tubes, and rolls of plastic	Extrudo Film Corp.
Extru-lite	Extruded thermoplastics	Rotuba Extruders, Inc.
Extrulon	For polyvinyl chloride	Omni Products Corp.
Extruvin	For polyvinyl chloride	Omni Products Corp.

F

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
FA	Furfuryl alcohol	The Quaker Oats Co.
50-B	Plasticizer	Plastics & Coal Chemicals Div., Allied Chemical Corp.
F.I.M.S.A.I. Spa	Injection molding machines, hydraulic pumps, and hydropneumatic accumulators	F.I.M.S.A.I. Spa
Fabmat	Woven roving and mechanically bonded glass mat, combined	Fiber Glass Industries, Inc.
Fabrez	Urea-formaldehyde textile resins	Reichhold Chemicals, Inc.
Febricfil	Chopped fabrics for filler in plastics	The Rayon Processing Co. of Rhode Island
Fabrikoid	Pyroxylin-coated fabrics	E. I. du Pont de Nemours & Co., Inc.
Fabrilite	Vinyl-coated fabrics	E. I. du Pont de Nemours & Co., Inc.
Fade-O-Meter	Testing apparatus for accelerated fading	Atlas Electric Devices Co.
Fairlite	Cellulose derivative	Shoe Form Co., Inc.
Fairlon	Polyethylene film	Chippewa Plastics, Inc., Div. of Rexall Drug & Chemical Co.
Fairprene	Synthetic rubber - coated fabrics	E. I. du Pont de Nemours & Co., Inc.
Fairylite	Plastic cellulose derivative in Class 1—raw or partly prepared materials	Shoe Form Co., Inc.
Famco-Fiber	Fabrics for laminating; fillers; fibrous glass for reinforcement	Famco, Inc.
Farlite	Decorative and industrial high-pressure laminate	Plastics Div., Farley & Loetscher Mfg. Co.
Farrel	Mills, calenders, extruders	Farrel-Birmingham Co., Inc.
Farrel-Birmingham	Mills, calenders, extruders	Farrel-Birmingham Co., Inc.
Fasslon	Vinyl coating	M. J. Fassler and Co., Inc.
Feather Brand	Balsa cores for reinforced plastics	International Balsa Corp.
Federan, Federlon, Fedwall	Vinyl-coated fabric	Federal Industries, Div. of Textron, Inc.
Fedlastic	Vinyl-coated jersey	Federal Industries, Div. of Textron, Inc.
Fedroid	Pyroxylin-coated fabric	Federal Industries, Div. of Textron, Inc.
Fenalac	Organic pigments used in coloring plastics	General Dyestuff Co., Div. of General Aniline & Film Corp.
Ferro	PVC heat and light stabilizer; organic inhibitors; epoxy stabilizers; blowing agent catalysts; and colors	Ferro Chemical Corp.
Ferrotron	Magnetic plastic materials	The Polymer Corp.
Fibercast	Reinforced plastic pipe and fittings	Fibercast Co.
Fibercore	Fibrous glass reinforced molding compounds	Plumb Chemical Corp.
Fiberfil	Glass reinforced nylon and styrene; injection molding compounds	Fiberfil, Inc.
Fiberesin	Laminated decorative board and panel stock	Fiberesin Plastics Co.
Fiberite	Reinforced phenolic and melamine molding materials	The Fiberite Corp.
Fiberthin	Coated textile fabric	United States Rubber Co.
Fibrez	Fibrous glass and premix molding compounds	General Plastics Corp. and General Fiber Inc., Div. of General Plastics Corp.
Filflox	Random cut fiber for filler in plastics	The Rayon Processing Co. of Rhode Island
Filfrac	Cut cotton fibre	Rayon Processing Co. of Rhode Island
Filon	Fibrous glass and nylon reinforced polyester building and decorative panels and glazing panes. The methods and equipment required in the continuous manufacturing process for making laminates	Filon Plastics Corp.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Firco	Plastic treatment for fire hose	General Plastics Mfg. Co.
Fire-Snuf	Flame-retardant, translucent polyester structural panels	Resolite Corp.
Flawmaster	A thermosetting compound used to reclaim metal parts and castings	Carl H. Briggs Co., Inc.
Flexbond	Polyvinyl acetate emulsion	Colton Chemical Co., Div. Air Reduction Co., Inc.
Flexol	Plasticizers	Union Carbide Chemicals Co.
Flexo-printer	Flexographic printing press	Wolverine Paper Converting Machine Corp.
Flexricin	Fatty ester plasticizers	The Baker Castor Oil Co.
Flexrite	Lacquer colors	Flexcraft Industries
Flexstron	A filament reinforced tape for heavy duty packaging	Mystik Adhesive Products, Inc.
Flomax	Liquid heat and light stabilizer for vinyl	National Lead Co.
Florence	Zinc oxides	New Jersey Zinc Co., The
Fluon	Fluorocarbon resin, extrusion	Imperial Chemical Industries, Ltd.
Fluorlastic	Process used in the manufacture of V- and L-type seals, diaphragms, etc.	Joclin Mfg. Co.
Fluorocell	Fluorocarbon seamless expulsion bags and bladders	Joclin Mfg. Co.
Fluoroflex-C	Rod, sheet, and tubing made from Kel-F	Resistoflex Corp.
Fluoroflex-T	Hose, rod, sheet, and tubing of Teflon	Resistoflex Corp.
Fluorogreen	Teflon compounded with glass and ceramic fiber	John L. Doré Co.
Fluorolin	Teflon tapes	Joclin Mfg. Co.
Fluorolubes	Plasticizers for fluorine-containing plastics	Hooker Chemical Corp.
Fluoroseal	Teflon-base thread compound	Industrial Plastic Fabricators, Inc.
Fluorosint	Reinforced TFE-fluorocarbon resin	The Polymer Corp.
Fluran	Fluorocarbon products	U. S. Stoneware Co.
Foamall	Foamed polyurethane compounds	Woodall Industries, Inc.
Fomrez	Resins for flexible and rigid foams	Witco Chemical Co., Inc.
Foramine	Urea-formaldehyde particle board adhesives	Reichold Chemicals, Inc.
Forasite	Phenol - formaldehyde particle board adhesives	Reichold Chemicals, Inc.
Formacolor	Color compounds	Westchester Plastics, Inc.
Formacurve	Formed decorative laminate	Pine-Wood Plastic Co.
Formadall	Reinforced polyester premix (sisal, glass, and/or synthetic fibers)	Woodall Industries Inc.
Format	Mechanically bonded glass mat	Fiber Glass Industries, Inc.
Formaton	Automatic molding presses	Guy P. Harvey & Son Corp.
Formold	Die steel	Crucible Steel Co. of America
Formpack	Thermoforming equipment for packaging	Hydro-Chemie, Ltd.
Formvac	Thermoforming equipment for industrial products	Hydro-Chemie, Ltd.
Formvar	Polyvinyl formal resins	Shawinigan Resins Corp.
Forticel	Cellulose propionate sheet films, molding powders	Plastics Div., Celanese Corp. of America
Fortiflex	Linear polyethylene	Plastics Div., Celanese Corp. of America
Fosta Nylon	Nylon resin	Foster Grant Co., Inc.
Fostarene	Polystyrene molding powders	Foster Grant Co., Inc.
Fosta Tuf-Flex	High-impact polystyrene	Foster Grant Co., Inc.
Foundrez	Urea-formaldehyde and phenol - formaldehyde foundry resins	Reichhold Chemicals Inc.
Franklin	Hard vulcanized fibre	Franklin Fibre-Lamitex Corp.
Fray-No-Therm	Heat sealable coating	Farrington Texol Corp.
Freeloader	Automatic blow-loading machinery	Whitso, Inc.
Frostwhite	Light, stable, medium-impact polystyrene	Sheffield Plastics, Inc.
Fuse Film	Film and film laminate	Velveray Corp.
Fyberold	High grade insulating paper ("Fish Paper")	Wilmington Fibre Specialty Co.
Fybrglas	Repair kits	Schramm Fiberglass Products, Inc.

G

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
G-K	Pipe joint compound	Atlas Mineral Products Co.
GRC	Tiny injection molded thermoplastic parts	Gries Reproducer Corp.
Gala	Casein	George Morrell Corp.
Galorn	Casein	George Morrell Corp.
Gamaco	Natural calcium carbonate extender	The Calcium Products Div., The Georgia Marble Co.
Garako	Accelerators for polyester resins	Garan Chemical Corp.
Garalease	Release agent films	Garan Chemical Corp.
Garalun	Aluminum oxide paper	Armour & Co., Coated Abrasives Div.
Garalyst	Photopolymerization peroxides (catalyst composition)	Garan Chemical Corp.
Garan	Glass fiber roving	Johns-Manville
Garan Finish	Sizing for glass fiber roving	The General Tire & Rubber Co.
Garnet H. T.	Heat treated garnet	Armour & Co., Coated Abrasives Div.
Garox	Peroxides	Garan Chemical Corp.
Gel-Kote	Coating for polyester products	The Glidden Co.
Gelva	Polyvinyl acetate resins	Shawinigan Resins Corp.
Gelvatex	Aqueous polyvinyl acetate emulsions and paint bases and paints	Shawinigan Resins Corp.
Gelvatol	Polyvinyl alcohol resins	Shawinigan Resins Corp.
Gemwood	Laminated sheets consisting of pregwoods combined with plastic sheets (acrylic, phenolic, acetate, etc.)	Gemwood Corp.
Gen-Flo	Styrene-butadiene latex	Chemical Div., General Tire & Rubber Co.
Gen-Mix	Reinforced pre-mix plastics	The General Tire & Rubber Co.
Genolon	Hard, unplasticized vinyl copolymer film and sheet	Kalle & Co., A. G.
Genotex	Yarn for weaving of plastic textiles	Kalle & Co., A. G.
Genotherm	Hard, unplasticized PVC film and sheet	Kalle & Co., A. G.
Geno-tubing	Hard, unplasticized PVC lay flat tubing	Kalle & Co., A. G.
Gen-Tac	Rubber-to-fabric vinyl pyridine adhesive dip	Chemical Div., General Tire & Rubber Co.
Genthane S	Millable gum urethane elastomer; prepolymer	The General Tire & Rubber Co.
Genton	Aqueous dispersions of nylon	General Dispersions, Inc.
Geon	Vinyl resins, casting materials, emulsions and dispersions; vinyl base and rubber base; vinyl chloride, vinyl chloride-vinylidene, other vinyls	B. F. Goodrich Chemical Co.
Gentron	Fluorinated hydrocarbon monomers and polymers	General Chemical Div., Allied Chemical Corp.
Ger-Flex	Vinyl tubing	Gering Products, Inc.
Gerlite	Acrylic sheeting	Gering Products, Inc.
Ger-Pak	Polyethylene film	Gering Products, Inc.
Ger-Tube	Polyethylene tubing	Gering Products, Inc.
Gilco	Polystyrene and polyethylene sheet	The Gilman Brothers Co.
Glamourglas	Decorative cast sheeting	Plastex Laminates, Inc.
Glas-Bond	Adhesive	Polymer Industries, Inc.
Glascel	Glass reinforcing material for decorative plastic laminates and electrical and structural parts	Riegel Paper Corp.
Glascomb	Glass facing to honeycomb	Plastex Laminates, Inc.
Glasdramatic	Process for drawing filaments of glass to shape and bonded with polyester or epoxy resin	Polygon Plastic Co.
Glaskyd	Glass-reinforced alkyd molding compound	Glaskyd, Inc.
Glastic	Glass-reinforced plastic	The Glastic Corp.
Glasticote	Cleaner-polish-protective coating: silicone oil and wax mold release agents	Industrial & Domestic Silicone Distributor
Glidpol	Basic material for molding, laminating, etc., of reinforced plastic products	The Glidden Co.
Glitex	Tubing for electrical insulation	Genesee Laboratory, Inc.
Globlak	Carbon black dispersion	Columbian Carbon Co.
Glopaque	Polyester and acrylic sheets and blanks with pearl effect	U. S. Plastic Products Corp.
Glykon	Polyester resin	Chemical Div., General Tire & Rubber Co.
Glyptal	Pigmented resin-base paints, varnishes, enamels, alkyd resins	Chemical Materials Dept., General Electric Co.
Goldcote	Gold-colored vacuum metalized finish	The Eyelet Specialty Co.
Golpanol	Protective coating for metal and anti-corrosive metal	Badische Anilin- & Soda-Fabrik AG
Goodallite	Vinyl-coated fabric	Goodall-Sanford, Inc.
Good-rite	Hydrophilic polymers, monomers, ozonic acids and chemical intermediates, adipates, phthalates, synthetic rubber	B. F. Goodrich Chemical Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Gravalum	Laminated aluminum and phenolic plastic engraving stock	New Hermes Engraving Machine Corp., Inc.
Gravoflex	Flexible laminated engraving stock	New Hermes Engraving Machine Corp., Inc.
Grex	High-density polyethylene	W. R. Grace & Co., Polymer Chemicals Div.
Gridkore	Lightweight partitions for packaging and as core material for translucent panels	Balsa Ecuador Lumber Corp.
Grieve-Hendry	Industrial and laboratory ovens and furnaces	Grieve-Hendry Co., Inc.
Griffco	PVA emulsions	Griffin Chemical Co., Sub. of Nopco Chemical Co.
Grip-Flex	Resin coating for plastics	Keystone Refining Co., Inc.
Griptex	Non-skid rug coating	Adhesive Products Corp.
Guard	Vinyl-coated fabric for wall covering	Columbus Coated Fabrics Corp.
Gummon	Organic cold mold material	Garfield Mfg. Co.
Gusco	Epoxy and epoxy-phenolic coatings	A. Gushmer, Inc.
Guttadur	Rigid PVC for technical application	Kalle & Co. A.G.
Guttagena	Clear flexible and semi-rigid PVC film and sheet	Kalle & Co. A.G.
Guttana-Glasklar	Calendered and polished clear film	Kalle & Co. A.G.
Gu-Tubing	Clear flexible PVC tubing	Kalle & Co. A.G.
Gymseal	Clear phenolic floor finish	McCloskey Varnish Co.

H

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Halowax	Chlorinated naphthalenes	Union Carbide Corp.
Hamilton	Precision gear hobbing machines; drilling machines; tapping machines	The Hamilton Tool Co.
Hammermatic	Air dry and baking enamels	Rexton Finishes, Inc.
Hands-Off 110	Hand cleaner for liquid polyester and epoxy resin workers.	Chemical Industries, Unit of E. F. Van Winkle Co.
Harflex	Plasticizers	Wallace & Tiernan, Inc.
Harmon	Color dispersions in resins and plasticizers	B. F. Goodrich Chemical Co.
Hartex	Vinyl film and sheeting	Harte & Co., Inc.
Hasko-Struct	Sandwich material (polyester resin-impregnated fiber-glass bonded to expanded foam)	Haskelite Mfg. Corp.
Haveg	Filled phenolic resin	Haveg Industries, Inc.
Haysite	Reinforced polyester	Hays Mfg. Co.
Heatrex	Clear and pigmented baking lacquer	Rexton Finishes, Inc.
Heilex	Plastic coatings	Heil Process Equipment Co.
Heirloom	Alkyd protective coating	McCloskey Varnish Co.
Heliogen	Phthalocyanine dyes used in coloring vinyl, etc.	General Dyestuff Co., Div. of General Aniline and Film Corp.
Heliozone	Inhibitor	E. I. du Pont de Nemours & Co., Inc.
Helix Bonding Agent	Epoxy resin adhesive	Carl H. Biggs Co., Inc.
Helix Flawmaster	Epoxy resin-metal putty	Carl H. Biggs Co., Inc.
Hemit	Inorganic cold mold material	Garfield Mfg. Co.
Hercocel	Cellulose acetate molding powder; ethyl cellulose molding powder	Hercules Powder Co., Inc.
Hercoflex	Plasticizers	Hercules Powder Co., Inc.
Hercolyn	Hydrogenated methyl abietate	Hercules Powder Co., Inc.
Hercules	Hot stamping presses	Acromark Co., The
Herecrol	Acrylonitrile-synthetic rubber	Heresite & Chemical Co.
Heresite	Phenolic coatings	Heresite & Chemical Co.
HET Acid	Basic material for polyester resins	Hooker Chemical Corp.
Hetron	Polyester resins	Durez Plastics Div., Hooker Chemical Corp.
Hexcel	Structural honeycomb	Hexcel Products, Inc.
Hexcelite	Decorative paneling using aluminum honeycomb and window glass	Hexcel Products, Inc.
Hi-fax	High-density polyethylene molding powder	Hercules Powder Co., Inc.
Hi-Viz	Fluorescent products	Lawter Chemicals, Inc.
Hobe	Honeycomb before expansion	Hexcel Products, Inc.
Holdertem	Prehardened steel for holders or retaining rings	Heppenstall Co.
Honey Cobond	Adhesives	Swedlow, Inc.
Horse Head	Zinc pigments and titanium dioxide pigments	New Jersey Zinc Co., The

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Hostaflon	Fluoroethylene resins, polytrifluorochloroethylene, and polytetrafluoroethylene	Farbwerke Hoechst AG., vormals Meister Lucius & Bruning
Hostalen	Polyolefins, low-pressure polyethylene, polypropylene	Farbwerke Hoechst AG., vormals Meister Lucius & Bruning
Hostalit	Polyterephthalic ester film	Kalle & Co. A.G.
Hostaphan	Polyvinyl chloride emulsion and suspension material	Farbwerke Hoechst AG., vormals Meister Lucius & Bruning
Hot Jet	Plastic welding equipment	D & R Plastic Welders, Inc.
Hot-Shot	Electric steam boiler	Automatic Steam Products Co.
Houze Hi Mod	Resin-loaded fibrous glass mat	Houze Glass Corp.
Hyben	Coated and waterproofed fabrics and film	Associated Rubber & Plastic Corp.
Hybond	Contact adhesive	Pierce & Stevens Chemical Corp.
Hycar	Emulsions and dispersions; rubber; butadiene-styrene; butadiene-acrylonitrile; acrylate	B. F. Goodrich Chemical Co.
Hycryl	Modified ammonium polyacrylate solution	U B S Chemical Corp.
Hydensel	Release papers	Mosinee Paper Mills Co.
Hydrawlik	Plastic tubing	Hydrawlik Co.
Hydrite	Extender and inert filler pigment	Georgia Kaolin Co.
Hydrocal & Hydrostone	Gypsum cements and mold material	United States Gypsum Co.
Hydrolair	Hydraulic presses	Elmes Engineering Div., American Steel Foundries
Hydromite	Resin gypsum mix for mold making	United States Gypsum Co.
Hydro-printer	Flexographic printing press	Wolverine Paper Converting Machine Corp.
Hyfac	Hydrogenated acids	Emery Industries, Inc.
Hylene	Organic isocyanates	E. I. du Pont de Nemours & Co., Inc.
Hylon	Special molded flexible polyurethane foams	The Englander Co., Inc.
Hypalon	Synthetic rubber	E. I. du Pont de Nemours & Co., Inc.
Hypervac	High vacuum pump	Central Scientific Co.
Hysol	Epoxy resin compounds and amine and anhydride hardners	Houghton Laboratories, Inc.
Hytrol	Solvent	E. I. du Pont de Nemours & Co., Inc.
Hy-tuf	Alloy steel	Crucible Steel Co. of America
Hyvac	High vacuum pump	Central Scientific Co.

I

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Ice-O-Lation	Prefabricated, modular, foamed-in-place insulating panels	The Englander Co., Inc.
Igepal	Surfactant; emulsifier; antistatic agent; wetting agent	Antara Chemicals, Div. of General Aniline & Film Corp.
Igepon	Surfactant; wetting agent	Antara Chemicals, Div. of General Aniline & Film Corp.
Impco	Plastics processing equipment	Improved Machinery, Inc.
Im-plast	High-impact, chemical resistant thermosetting materials	The Richardson Co.
Implex	Modified acrylic molding powder	Rohm & Haas Co.
Inceloid	Plastic sheeting, adhesives, lacquers	American Products Mfg. Co.
Ind	Thermosetting and thermoplastic molding materials	Industrial Molded Products Co., Inc.
Indusol	Vinyl plastisols and organosols	Industrial Solvents & Chemicals, Inc.
Instaset Plastics	Plastics	Evans-Winter-Hebb, Inc.
Insulfoam	Open-cell polyester foam thermal insulation	Robinson Foams, Ltd.
Insulstric	Fibrous glass-polyester laminate	Cincinnati Development & Mfg. Co.
Insultruc	Fibrous glass-polyester laminate	Cincinnati Development & Mfg. Co.
Insurok	Laminated plastic sheet, tubes, gears, blanks, washers, discs, special molded parts	The Richardson Co.
Interplastics	Thermoplastic molding powders	Interplastics Corp.
Intraplast	Plastic sheeting	Intraplast Mfg. Co.
Iolyte	Reinforced plastic fabrications	Schori Process, Div. Ferro-co Corp.
Iosol	Solvent soluble dyes	National Aniline Div., Allied Chemical Co.
Iporka	Urea resin and foam	Badische Anilin- & Soda-Fabrik AG
Irgaplast Colours	Organic pigments	J. R. Geigy, S.A.
Irvington	Coated and laminated products	Minnesota Mining & Mfg. Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Irvinil	Polyvinyl chloride resin	Great American Plastics Co.
Isanol	Lacquer solvent	Badische Anilin- & Soda-Fabrik AG
Isobestos	Isocyanate (polyurethane) resin-coated asbestos	Natvar Corp.
Isoflex	Crack-resistant polyethylene tubing	Keystone Plastics, Inc.
Isolastane	Isocyanate (polyurethane) elastomer-coated glass cloth	Natvar Corp.
Isoglas	Isocyanate (polyurethane) resin-coated glass cloth	Natvar Corp.
Isolite	Polyester resin	Schenectady Varnish Co.
Isolon	Rigid polyurethane foam insulation	The Englander Co., Inc.
Isomelt	Polyurethane wire enamel	Schenectady Varnish Co., Inc.
Isonel	Polyester wire enamel	Schenectady Varnish Co., Inc.
Isoplast	Depolymerized rubber	Rubber & Asbestos Corp.
Isoplex	Duplex isocyanate (polyurethane) resin-coated glass cloth	Natvar Corp.
Ivo	Bone black	Columbian Carbon Co.

J

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
JRCO 98	Polymeric amides homogenized with internal lubricants	Jim Robbins Co.
Javollal	Citronella odorant	Fritzche Brothers, Inc.
Jek-O-Mer	Liquid alkyd resin and solutions for use as coating compositions and as vehicles in paints and enamels	Alkydol Laboratories, Inc.
Jel-O-Mer	Alkyd resins and solutions	Alkydol Laboratories, Inc.
Jetflo	Injection molding machine	Reed-Prentice, Div. of Package Machinery Co.
Jet-Kote	Furane resin coatings	Furane Plastics, Inc.
Joda	Thermoplastic sheets and film	Joseph Davis Plastics Co.
Johnson's Wax	Wax products used as mold release agents	S. C. Johnson & Son, Inc.
Jolite	Bottles, jars, and containers	Lermer Plastics, Inc.

K

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Kadox	Zinc oxides	New Jersey Zinc Co., The
Kalite	Precipitated calcium carbonate, fatty acid coated	Diamond Alkali Co.
Kandar	Thermoplastic resin emulsion	U.S. Rubber Co.
Kapsol	Plasticizers (oleate)	Ohio-Apex Div., F. M. C.
Kaston	Phenolic casting resins	Poly Resins
Kauresin-Leim	Phenol-formaldehyde resins	Badische Anilin- & Soda-Fabrik AG
Kaurit-Leim	Urea-formaldehyde resin	Badische Anilin- & Soda-Fabrik AG
Kel-F	Fluorocarbon molding powder and products	Minnesota Mining & Mfg. Co.
Kenflex	Synthetic hydrocarbon resin and plasticizers	Kenrich Corp.
Kenmix	Rubber accelerator dispersions	Kenrich Corp.
Kentrall	Combination hardness testers	The Torsion Balance Co.
Kentron	Micro hardness testers	The Torsion Balance Co.
Keracloth, Keralith, & Keratol	Pyroxylin impregnated cloth	Textileather Div., The General Tire & Rubber Co.
Kessco	Plasticizers, surface active agents	Kessler Chemical Co., Inc.
Ketac	Ketone-aldehyde resin	American Cyanamid Co.
Ketos	Tool steel	Crucible Steel Co. of America
Kevinite	Decorative plastic laminate	Swedlow, Inc.
Kingcote	Cut cotton fibre	Rayon Processing Co. of Rhode Island
Klearcor	Polyethylene pipe with clear interior and a black extruded sheath	Western Plastics Corp.
Kling-Seal	Thermoplastic-coated sheet	Milprint, Inc.
Ko-Blend	Insoluble sulfex-GR-master batch	General Tire & Rubber Co.
Kodapak Sheet (I)	Cellulose acetate	Eastman Kodak Co.
Kodapak Sheet (II)	Cellulose acetate butyrate	Eastman Kodak Co.
Kodapak Sheet (IV)	Cellulose triacetate	Eastman Kodak Co.
Kodel	Polyester fiber	Tennessee Eastman Co., Div. of Eastman Kodak Co.
Koloc	Resin compositions for cotton, rayon, and wool	United States Rubber Co.
Kopol	Processed congo copals	Reichhold Chemicals, Inc.
Koresin	Vinyl resin on a phenolic base for the rubber industry	Badische Anilin- & Soda-Fabrik AG
Korez	Rubber-base coating	Atlas Mineral Products Co.
Koroseal	Vinyl-coated fabrics, vinyl film and sheet, vinyl extrusions, plastisol compounds, etc.	B. F. Goodrich Industrial Products Co., Div. B. F. Goodrich Co.
Kotol	Resin solution for adhesives and castings	United States Rubber Co.
Kralac	Rubber compounding resins and plastic latices	Naugatuck Chemical Div., United States Rubber Co.
Kralastic	Molding and extrusion powders and flexible latices	Naugatuck Chemical Div., United States Rubber Co.
Krene	Plasticized calendered vinyl chloride-acetate film and sheeting and cast vinyl film	Union Carbide Plastics Co., Div. of Union Carbide Corp.
Kromoplast	Dry colorant for thermoplastics	American Molding Powder & Chemical Corp.
Kronisol	Dibutoxyethyl phthalate plasticizer	Ohio-Apex Div., Food Machinery & Chemical Corp.
Kronite	Tricresyl phosphate plasticizer	Ohio-Apex Div., Food Machinery & Chemical Corp.
Krumbhaar	Resins	Lawter Chemicals, Inc.
Krylon	Plastic coating	Krylon, Inc.
Kryolith	Mineral filler	Pennsalt Chemicals Corp.
Kunstharz	Unsaponifiable synthetic resin, based on ketones; alcohol-soluble resin for nitrocellulose	Badische Anilin- & Soda-Fabrik AG
Kure-Blend	Tetramethyl Thiuramdisulfide-GR-S	General Tire & Rubber Co., Chemical Div.
Kwik-Klamp	Resin adhesive for structural assemblies	National Starch Co.

L

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Lactoid	Casein	BX Plastics Ltd.
Ladcote	Thermoplastic compounds	L. A. Dreyfuss Co.
Lamicoid	Laminated thermosetting sheets, rods, tubes,	Mica Insulator Div., Minnesota Mining & Mfg. Co.
Lamidall	Decorative polyester laminate	Woodall Industries, Inc.
Laminac	Polyester resins	American Cyanamid Co.
Lamin-Art	High-pressure melamine decorative laminates	Fabricon Products, Div. of Eagle-Picher Co.
Lamitex	Laminated plastics in sheets, rods, tubes, screw machine parts, stampings, etc.	Franklin Fibre-Lamitex Corp.
Larcrylic	Acrylic sheet	Larc Products, Inc.
Laromin	Hardener for epoxies	Badische Anilin- & Soda-Fabrik AG
Laropal	Modified ester for rapidly drying oil, alkyd, alcohol lacquers, etc.	Badische Anilin- & Soda-Fabrik AG
Latekoll	Thickening agent for dispersions	Badische Anilin- & Soda-Fabrik AG
Latyl	Dyes	E. I. du Pont de Nemours & Co., Inc.
Lauxein	Casein and soybean adhesives	Monsanto Chemical Co.
Lauxite	Urea and melamine adhesives	Monsanto Chemical Co.
Layflat	Plastic tubing	Plax Corp.
Lecton	Acrylic resin-coated fabrics and laminates	E. I. du Pont de Nemours & Co., Inc.
Lectro "60"	Stabilizer for vinyl electrical insulations	National Lead Co.
Leefluor	Teflon rods, sheets, tubes and molded or fabricated parts made of Teflon	Walt Lee Chemical Corp.
Lemac	Polyvinyl acetate	The Borden Chemical Co.
Lemol	Polyvinyl alcohol	The Borden Chemical Co.
Leucogen	Dyes	E. I. du Pont de Nemours & Co., Inc.
Leucosol	Dyes	E. I. du Pont de Nemours & Co., Inc.
Lexan	Polycarbonate	General Electric Co.
Lignocol	Anti-skinning agent	Heyden Newport Chemical Corp.
Like Magic	Anti-static and cleaner	Merchandise Presentation, Inc.
Lintex	Vinyl-coated fabric for table coverings	Columbus Coated Fabrics Corp.
Liquamatte	Wet blast polishing and honing machines	Techline Div., Wheelabrator Corp.
Liquasheen	Wet blast abrasives	Techline Div., Wheelabrator Corp.
Lithosol	Dyes	E. I. du Pont de Nemours & Co., Inc.
Logo	Solutions of organic polymeric substances	Bee Chemical Co.
Logofoil	Strippable protective coating composition	Bee Chemical Co.
Logoquant	Chemical preparations and protective coating composition for use on plastics	Bee Chemical Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Logoset	Synthetic enamels and varnishes	Bee Chemical Co.
Lorco	Tumbling barrels, media, and compounds for plastics finishing	Lord Chemical Corp.
Lorol	Fatty alcohol	E. I. du Pont de Nemours & Co., Inc.
Lotol	Compounded latices	Naugatuck Chemical Div., United States Rubber Co.
Loxite	Elastomeric adhesives	Xylos Rubber Co., Div. of Firestone Tire & Rubber Co.
Luaktin	Rapidly evaporating surface coating for oil alkyd lacquers	Badische Anilin- & Soda-Fabrik AG
Lucidol	Benzoyl peroxide	Lucidol Div., Wallace & Tiernan, Inc.
Lucite	Acrylic	E. I. du Pont de Nemours & Co., Inc.
Ludox	Colloidal silica	E. I. du Pont de Nemours & Co., Inc.
Lumarith	Cellulose acetate sheet, film, molding powders	Plastics Div., Celanese Corp. of America
Lumigraphic	Fluorescent pigments	Imperial Paper & Color Corp.
Lunlite	Glass fiber reinforced plaster	Lunn Laminates, Inc.
Lunnlease	Mold release agent	Lunn Laminates, Inc.
Luperco	Organic peroxide compounds	Lucidol Div., Wallace & Tiernan, Inc.
Luperox	Organic peroxide pastes	Lucidol Div., Wallace & Tiernan, Inc.
Lupersol	Organic peroxide solutions	Lucidol Div., Wallace & Tiernan, Inc.
Luphen	Hardenable phenolic resin for chemical resistant lacquers and resistant coatings	Imperial Paper and Color Corp., Pigment Color Div.
Lupolen	Polyethylene	Lupoline Automatic Polishing Equipment Corp.
Lupoline	Tumbling barrels and compounds	Badische Anilin- & Soda-Fabrik AG
Lusane	Brilliant blue B dye	E. I. du Pont de Nemours & Co., Inc.
Lustreglow	High luster pearlescent acrylic sheets and blanks	U. S. Plastic Products Corp.
Lustrelite	Smooth and patterned pearlescent acrylic sheets and blanks	U. S. Plastic Products Corp.
Lustretone	High luster pearlescent polyester sheets and blanks	U. S. Plastic Products Corp.
Lustrex	Styrene molding and extrusion compounds	Monsanto Chemical Co.
Lutofan	Polyvinyl chloride emulsion	Badische Anilin- & Soda-Fabrik AG
Lutonal	Polyvinyl ether	Badische Anilin- & Soda-Fabrik AG
Luvican	Polyvinyl carbazole (heat-resistant; especially for electronic applications)	Badische Anilin- & Soda-Fabrik AG
Luxol	Dyes	E. I. du Pont de Nemours & Co., Inc.
Lytron	Unplasticized polystyrene emulsions (textile resin)and latices for surface coatings	Monsanto Chemical Co.

M

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
MC-1	Cyclahexanone peroxide paste	Plastics Div., Celanese Corp. of America
M.D.A.	Methylene disalicylic acid technical	Heyden Newport Chemical Corp.
M & M	Disintegrating machines, etc.	Mitts & Merrill Inc.
MPS-500	Chlorinated fatty acid esters for PVC formulations which is used as a vinyl plasticizer	Hooker Chemical Corp.
M.T.D.	Molded items for underground construction	Plymouth Industrial, Inc.
Madurit	Melamine resins for plastics industry	Cassella Farbwerke Mainkur, A.G.
Magic-Vulc	Adhesives and coatings	Magic Chemical Co.
Maimin	Portable straight and round knife cutting machines	H. Maimin Co., Inc.
Mapico	Synthetic iron oxide pigments	Columbian Carbon Co.
Maprenal	Melamine resins for varnish industry	Cassella Farbwerke Mainkur, A.G.
Maraset	Liquid epoxy resin	The Marblette Corp.
Marbelite	Reinforced plastic composition used in casting	George J. Kreier & Son
Marblette	Liquid phenolic resin	The Marblette Corp.
Marbon 8000	High styrene resins	Borg-Warner Corp.
Marco	Polyester resins	Plastics Div., Celanese Corp. of America
Marcothix	Thixotropic polyester resins	Plastics Div., Celanese Corp. of America

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Marion mixer	Mixing and blending machines	Rapids Machinery Co., Inc.
Mark	Stabilizers	Argus Chemical Corp.
Marlex	Olefin polymer	Phillips Chemical Co.
Marmix	Resin emulsions	Marbon Chemical Div., Borg-Warner Corp.
Marvibond	Metal-plastic laminates	Naugatuck Chemical Div., United States Rubber Co.
Marvinol	Polyvinyl chloride resins	Naugatuck Chemical Div., United States Rubber Co.
Masland Duran	Vinyl upholstery	The Masland Duraleather Co.
Master Color	Concentrated pigment dispersions for thermoplastics materials	American Molding Powder & Chemical Corp.
Max-el	Free machining steel	Crucible Steel Co. of America
Meadmatic	Air valves, air timers	Mead Specialties Co.
Mearlmaid	Natural pearl essence	The Mearl Corp.
Megavac	High vacuum pump	Central Scientific Co.
Melurac	Melamine-urea adhesive resins	American Cyanamid Co.
Merac	Water-soluble rubber latex accelerator	Pennsylvania Salt Mfg. Co., Industrial Div.
Mercadium	Cadmium mercury in colors	Imperial Paper & Color Corp.
Merix Anti-Fog	Fog-preventative chemical for plastics	Merix Chemical Co.
Merix Anti-Static	Antistatic for plastics	Merix Chemical Co.
Merpentine	Surface active agent	E. I. du Pont de Nemours & Co.
Merpol	Surface active agent	E. I. du Pont de Nemours & Co.
Metaflex	Coated textile fabric with polished metal appearance	L. E. Carpenter & Co.
Metaplex	Vacuum metallizing	Sullivan Chemicals
Metalset	Metal-filled epoxy formulations	Smooth-On Mfg. Co.
Metasap	Metallic soaps and stabilizers	Metasap Chemical Co., Sub. of Nopco Chemical Co.
Methac	Methanol-methyl acetate	The Borden Chemical Co.
Methaflex	Plastic sheet	Plax Corp.
Methocel	Methylcellulose	Dow Chemical Co.
Methox	Dimethoxyethyl phthalate plasticizer	Ohio-Apex, Div. F.M.C.
Methylon	Phenolic coating resin	General Electric Co., Chemical Materials Dept.
Metlbond	Structural sandwich and metal-to-metal adhesive	Narmco Resins & Coatings Co.
Micabond	Bonded mica	Continental-Diamond Fibre Corp.
Miccron resins	Resin for fluidized bed coating	Michigan Chrome & Chemical Co.
Miccrosol	Vinyl plastisols	Michigan Chrome & Chemical Co.
Micro Mica	Finely ground mica	The English Mica Co.
Micronex	Carbon black	Columbian Carbon Co.
Microsurfacer	Sizing machine for surfacing thin sheeting	Buss Machine Works
Microtomatic	Precision slicing & dicing machines	The DoAll Co.
Micro-vent	Porous vinyl film	Canadian Resins and Chemicals, Ltd.
Midas	Bronze dispersion	Argus Chemical Corp.
Midlon	Extruded sheeting	Midwest Plastic Products Co.
Milam	Laminated packaging material	Milprint, Inc.
Millical	Precipitated calcium carbonate	The Diamond-Alkali Co.
Mil-O-Film	Plastic sheets, bags, and wrappers	Milprint, Inc.
Mini-Jector	Injection molding machines	Newbury Industries, Inc.
Mipolam	PVC copolymers	Dynamit-Actien-Gesellschaft
Miracle	Adhesives and coatings	Miracle Adhesives Corp.
Mirasol	Alkyd resins	C. J. Osborn Co.
Mirro-Brite	Metallized acetate, butyrate, styrene, and polyester film and sheet	Coating Products
Mirromold	Mold-steel	The Carpenter Steel Co.
Mobaloy	Synthetic fabrics, glass roving, glass-filled molding compounds	Cordo Molding Products, Inc.
Mobay	Organic chemicals including isocyanates, carbamyl halides; synthetic resins, including polyesters; chemical intermediates for polyurethanes; catalysts and other additives for use in making polyurethane plastics; polyurethane foam; etc.	Mobay Chemical Co.
Modiglass	Surfacing and decorative mats and veils; continuous fiber reinforcing mats; chopped fiber flake; unidirectional reinforcing mats and tapes; chopped strands	Modiglas Fibers, Inc.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Modulene	Polyethylene resin and molding compound	H. Muehlstein & Co., Inc.
Modulite	Modular fibrous glass-polyester building, glazing, and decorative panels; sandwich panels	Modular Molding Corp.
Mogul	Channel carbon blacks	Godfrey L. Cabot, Inc.
Mold-Eze	Mold lubricant	Moldrite Products Co.
Moldmaster	Injection Molding Machine	Crown Machine & Tool Co.
Molacco	Carbon Black	Columbian Carbon Co.
Moldtem	Prehardened steel for molds	Heppenstall Co.
Molgard	Internal mold release products	Garan Chemical Corp.
Monarch	Medium color channel carbon blacks	Godfrey L. Cabot, Inc.
Monarchrome	Colors made by precipitating phthalocyanine	Imperial Paper & Color Corp.
Mondur	Isocyanates and synthetic resins (including polyesters)	Mobay Chemical Co.
Monite	Casein adhesives	Monite Waterproof Glue Co.
Monofast	Pigments	H. Kohnstamm & Co., Inc.
Monopeen	Paints, varnishes, enamels, etc.	Interchemical Corp.
Monopentek	Monopentaerythritol	Heyden Newport Chemical Corp.
Moplen	Polypropylene	Chemore Corp.
Morcowet	Wetting agents	Morton Withers Chemical Co.
Morester	Polyester resins	Morton Withers Chemical Co.
Morflex	Plasticizers	Morton Withers Chemical Co.
Morsperse	Dispersing agents	Morton Withers Chemical Co.
Moviol	Polyvinyl alcohol	Farbwerke Hoechst AG. vormals Meister Lucius & Bruning
Multifex MM	Precipitated calcium carbonate, ultrafine	Diamond-Alkali Co.
Multiform	Saws, benders, cutter, bridgers, dies	J. A. Richards Co.
Multi-Lok	Resin base adhesive	National Starch Co.
Multiplastics	Reinforced plastics for industrial repairs and boat coverings (in kit form)	Curd Enterprises, Inc.
Multipruf	Vinyl-coated fabric	Elm Coated Fabrics Co., Inc.
Multi-Table	Table-type mechanical deflashing machines	Wheelabrator Corp.
Multiwave	Formable core material	Narmco Resins & Coatings Co.
Multranil	Synthetic resins and catalysts for use in making polyurethanes	Mobay Chemical Co.
Multrathane	Urethane elastomer chemicals	Mobay Chemical Co.
Multron	Synthetic resins (including polyesters)	Mobay Chemical Co.
Mustang	Composition base sheet-supported vinyl	Textileather Div., The General Tire & Rubber Co.
Mycalex	Glass-bonded mica	Mycalex Corp. of America
Mykroy	Glass-bonded mica	Electronic Mechanics, Inc.
Mylar	Polyester film	E. I. du Pont de Nemours & Co., Inc.
Myleroy	Glass-bonded mica	Electronic Mechanics, Inc.
Myltite	Rolled nylon sleeves and washers	Keystone Plastics, Inc.
Mystik	Pressure-sensitive cloth tapes	Mystik Adhesive Products, Inc.

N

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
NP 10	Polymeric plasticizer	Eastman Chemical Products, Inc.
NR	Polyester resins	Plastics Div., Celanese Corp. of America
NR Pliolite	Cyclized rubber coating resins	The Goodyear Tire and Rubber Co.
Nacconate	Diisocyanate	National Aniline Div., Allied Chemical Corp.
Nacconol	Detergent	National Aniline Div., Allied Chemical Corp.
Naccosol	Wetting agents	National Aniline Div., Allied Chemical Corp.
Naccotan	Dispersing agent	National Aniline Div., Allied Chemical Corp.
Nacriner & Nacromer	Synthetic pearl pigments	Mearl Corp.
Nadic	Anhydride for alkyds and polyesters	National Aniline Div., Allied Chemical Corp.
Nalco	Infra-red lamps	North American Electric Lamp Co.
Nalzin	Zinc stabilizer for use in vinyl	National Lead Co.
Napolex	Extruded thermoplastic tubing	British Moulded Plastics Ltd.
Napthanil	Diazo colors	E. I. du Pont de Nemours & Co.
Narmcloth	Coated fabrics and pre-impregnated laminating materials	Narmco Resins & Coatings Co.
Narmtape	Adhesive for sandwich constructions	Narmco Resins & Coatings Co.
Natco	Machine tools	National Automatic Tool
Naugahyde	Vinyl-coated fabric	United States Rubber Co.
Naugapol	Synthetic rubber	Naugatuck Chemical Div., United States Rubber Co.
Naugatex	Butadiene-styrene latices	Naugatuck Chemical Div., United States Rubber Co.
Naugatuck	Plasticizers	Naugatuck Chemical Div., United States Rubber Co.
Nebony	Petroleum hydrocarbon resin	Neville Chemical Co.
Neelium	Extra-heavy-duty neoprene coatings	Atlas Mineral Products Co.
Nekol	Wetting agent	Antara Chemicals, Sales Div., General Aniline & Film Corp.
Neobon	Neoprene coating	Atlas Mineral Products Co.
Neomerpin	Surface active agents	E. I. du Pont de Nemours & Co., Inc.
Neo-Spectra	Carbon black	Columbian Carbon Co.
Neozone	Rubber anti-oxidants	E. I. du Pont de Nemours & Co., Inc.
Nepoxide	Epoxy coating	Atlas Mineral Products Co.
Neutroleum	Odor modifier for rubber, vinyl, and plasticizers	Fritzche Brothers, Inc.
Neutroscent	Perfume for surface dressing of finished plastics	Fritzche Brothers, Inc.
Nevamar	High-pressure decorative laminates	The National Plastics Products Co.
Nevillac	Phenol-modified coumarone-indene resin	Neville Chemical Co.
Neville LX-685	Petroleum hydrocarbon resin	Neville Chemical Co.
Nevindene	Coumarone-indene resin	Neville Chemical Co.
Nevinol	Plasticizing oil	Neville Chemical Co.
Nevsolv	Hydrocarbon solvent	Neville Chemical Co.
Niacet	Vinyl acetate	Union Carbide Chemicals Co., Div. of Union Carbide Corp.
Niax	Polyol polyethers for use in manufacture of urethane products	Union Carbide Chemicals Co., Div. of Union Carbide Corp.
Nibrocel	Base stock for high-pressure laminates	Brown Co.
Nicoform	Electroformed cavities	Electromold Corp.
Nitrex	Synthetic rubber latices	Naugatuck Chemical Div., United States Rubber Co.
Nitrocol	Nitrocellulose base pigment dispersion	C. J. Osborn Co.
Non-Fer-Al	Precipitated calcium carbonate, high purity	Diamond Alkali Co.
Nolane	Fiberglass finishing agent	New York Quinine & Chemical Works, Div. of S. B. Penick & Co.
Non-flam	Cellulose derivative	Shoe Form Co., Inc.
Nonic	Nonionic wetting agents	Pennsalt Chemicals Corp.
Nopco	Polyurethane foam	Nopco Chemical Co.
Nopcocell	Polyurethane foam (flexible)	Nopco Chemical Co.
Nopcofoam	Polyurethane foam (flexible)	Nopco Chemical Co.
Nopco Lockfoam	Polyurethane foam (foam-in place)	Nopco Chemical Co.
Normasal	Stabilizer for vinyl chloride flooring	National Lead Co.
Norplex	Laminated plastics	Northern Plastics Corp.
Novabestos	Asbestos and/or glass reinforcement and electrical insulation	Raybestos-Manhattan, Inc., Reinforced Plastics Dept.
Nuba	Modified coumarone-indene resin	Neville Chemical Co.
Nuplaflex	Compounded plastic material	New Plastic Corp.
Nuseal	General mixing varnish	McCloskey Varnish Co.
Nygen Tolex	Supported vinyl	Textileather Div., General Tire & Rubber Co.
Nylaflow	Nylon pressure tubing	The Polymer Corp.
Nylam	Nylon film and film laminates	H & R Industries
Nylasint	Sintered nylon parts	The Polymer Corp.
Nylatint	Nylon dyes	The Polymer Corp.
Nylatron	Filled nylons	The Polymer Corp.
Nylaweld	Nylon-to-nylon adhesives	The Polymer Corp.
Nynel	Nylon and film laminate	Velveray Corp.

O

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Ocenol	Oleyl alcohol	E. I. du Pont de Nemours & Co., Inc.
Ohio-Apex	Plasticizers, monomers, plastics	FMC Organic Chemicals Div., Food Machinery & Chemical Corp.
Ohmoid	Laminated phenolic	Wilmington Fibre Specialty Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Ohopex	Specialty plasticizers	FMC Organic Chemicals Div., Food Machinery & Chemicals Corp.
Olin Polyethylene	Polyethylene	Olin Mathieson Chemical Corp.
Omnicolor	For pigments and dyes in plastics	Omni Products Corp.
Omnylon	Nylon	Omni Products Corp.
Omya	Chalk whiting	Pluess-Staufer (North American)
Opalon	Vinyl chloride (resins and compounds)	Monsanto Chemical Co.
Oppanol B	Polyisobutylene	Badische- Anilin- & Soda-Fabrik AG
Oppanol C	Polyvinylisobutyl ether	Badische- Anilin- & Soda-Fabrik AG
Orlon	Acrylic fiber	E. I. du Pont de Nemours & Co., Inc.
Oronite	Chemicals for use in industrial arts and sciences	Oronite Chemical Co.
Oxidex	Anti-oxidant for animal and vegetable fats and oils	Fritzche Brothers Inc.
	P	
P. H. I.	Hydraulic presses	Pasadena Hydraulics, Inc.
P. I. P.	Asphalt & resin thermoplastic molding composition	Plymouth Industrial Products, Inc.
PHT polyethylene Omni	High-pressure polyethylelene	Omni Products Corp.
PPG	Yarn; chopped strands and roving	Pittsburgh Plate Glass Co.
P.V.C.	Plastic pipe compound	Schwartz Chemical Co.
Paladin	Primers for plastics	Interchemical Corp., Finishes Div.
Palatal	Polyester cast resin	Badische Anilin- & Soda-Fabrik AG
Palatinol	Softeners for lacquers, plastics, and film forming materials	Badische Anilin- & Soda-Fabrik AG
Panaflex	Hydrocarbon plasticizer	Amoco Chemicals Corp.
Panalon	Resin finish; resin dispersion	E. I. du Pont de Nemours & Co., Inc.
Panarez	Hydrocarbon resins	Amoco Chemicals Corp.
Panelcomb	Embossed cast sheeting	Plastex Laminates, Inc.
Pantasote	Vinyl-coated fabric	The Pantasote Co.
Pantex	Unsupported vinyl film	The Pantasote Co.
Panther	Plastic pipe and fittings	Western Plastics Corp.
Paracril	Synthetic rubber (oil-resistant)	Naugatuck Chemical Div., United States Rubber Co.
Paraplex	Polyester resins	Rohm & Haas Co.
Parasepts	Esters of para-hydroxy benzoic acid, preservatives	Heyden Newport Chemical Corp.
Parcloid	Vinyl resin dispersions (vinyl chloride and vinyl chloride-acetate resins)	Parcloid Chemical Co.
Parilin	Saturated fatty ester plasticizers	The Baker Castor Oil Co.
Part-A-Part	Release agent films	Garan Chemical Corp.
Patapar	Casting sheet for polyurethane foams, organic adhesives, organosols, and alkyd films	Paterson Parchment Paper Co.
Peerless	Electrical insulation	National Vulcanized Fibre Co.
Pee Vee Cee	Rigid plastic pipe	Atlas Mineral Products Co.
Pelaspan	Expandable polystyrene	Dow Chemical Co.
Pentacite	Pentaerythritol resins	Reichhold Chemicals, Inc.
Pentalene	Amyl naphthalenes	Pennsalt Chemicals Corp.
Pentaphen	Para-tert-amylphenol	Pennsalt Chemicals Corp.
Pent-Acetate	Synthetic amyl acetates	Pennsalt Chemicals Corp.
Pentasol	Synthetic amyl alcohol	Pennsalt Chemicals Corp.
Pentek	Pentaerythritol technical	Heyden Newport Chemical Corp.
Penton	Chlorinated polyether	Hercules Powder Co.
Perciene	Perchlorethylene	E. I. du Pont de Nemours & Co., Inc.
Permacel	Films, resins, adhesives, coatings, and resin coatings	Permacel
Permagen	Organic pigments used for coloring plastics	General Dyestuff Co., Div. of General Aniline & Film Corp.
Permalux	Neoprene accelerator	E. I. du Pont de Nemours & Co., Inc.
Permansa	Colorants (yellow, red, green, and orange)	The Sherwin Williams Co.
Perma-Skin	Vinyl and epoxy coatings	Dennis Chemical Co.
Permelite	Melamine molding compounds	Melamine Plastics, Inc.
Permelite	Plastic molding compounds	The Fiberite Corp.
Permolith	Lithopone	The Sherwin Williams Co.
Permyl B-100	Ultra-violet screener	Ferro Chemical Corp.
Perspex	Acrylic sheet and rod	Imperial Chemical Industries, Ltd.
Petrothene	Polyethylene resin	U. S. Industrial Chemicals Co., Div. National Distillers and Chemical Corp.
Petrowet	Surface active agents	E. I. du Pont de Nemours & Co., Inc.
Phenolite	Laminated plastics	National Vulcanized Fibre Co.
Phenopreg	Preimpregnated papers, fabrics, glass cloth, and glass and sisal mat	Fabricon Products, Div. of Eagle-Picher Co.
Phenoweld	Phenolic adhesive	H. V. Hardman Co., Inc.
Phtalopal	Alcohol soluble phthalic resins for nitrocellulose wood lacquers	Badische- Anilin- & Soda-Fabrik AG
Picco	Hydrocarbon resins	Pennsylvania Industrial Chemical Corp.
Piccolyte	Terpene polymer resin	Pennsylvania Industrial Chemical Corp.
Piccolastic	Styrene polymer resin	Pennsylvania Industrial Chemical Corp.
Piccopale	Petroleum resin	Pennsylvania Industrial Chemical Corp.
Piccosize	Petroleum resin emulsion	Pennsylvania Industrial Chemical Corp.
Piccocizer	Plasticizer	Pennsylvania Industrial Chemical Corp.
Piccoflex	Styrene copolymer resins	Pennsylvania Industrial Chemical Corp.
Piccoumaron	Hydrocarbon resins	Pennsylvania Industrial Chemical Corp.
Piccovar	Hydrocarbon resins	Pennsylvania Industrial Chemical Corp.
Pigment	Partially calcined clay used in polyvinyl chloride compounding	Southern Clays, Inc.
Pinto	Composition base sheet-supported vinyl	Textileather Div., The General Tire & Rubber Co.
Pionite	Decorative, high-pressure melamine laminates	Pioneer Plastics Corp.
Pittsburgh PX	Prefix denotes plasticizers made by company	Pittsburgh Coke & Chemical Co.
Placo	Hydraulic laminating presses; laminated products	Plastic Laminating Corp.
Placquer	Semi-gloss acrylic paint	Custom Coatings Co.
Plascor	Buffing compounds for plastics	United Laboratories Co.
Plaskon	Line of resins and molding compounds (e.g. nylon 6, etc.)	Plastics & Coal Chemicals Div., Allied Chemical Corp.
Plaspreg	Furane resin-impregnated compound	Furane Plastics, Inc.
Plastacele	Cellulose acetate	E.I. du Pont de Nemours & Co., Inc.
Plastaplex	Coatings for polystyrene	Sullivan Chemicals
Plastex	Line of pipe, shapes, etc.	The Plastex Co.
Plasticone	Colorants (red)	The Sherwin Williams Co.
Plasti-cut	Screen process stencil films	Ulano Products Co.
Plastigen	Soft resins for lacquers, based on nitrocellulose & other film formers	Badische Anilin- & Soda-Fabrik AG
Plastikon	Adhesive (general purpose and cement putties)	The B. F. Goodrich Industrial Products Co., Div. B. F. Goodrich Co.
Plastilock	Rubber-resin thermo-setting structural adhesives	B. F. Goodrich Industrial Products Co., Div. B. F. Goodrich Co.
Plastimayd	Vinyl film and sheet products	Plastimayd Products Corp.
Plastisand	Resin-coated sand for shell molding	Acme Resin Corp.
Plasto	Dyes for plastics and lacquer	National Aniline Div., Allied Chemical Corp.
Plastoflex	Vinyl plasticizer (epoxidized soya type and ester type)	Advance Solvents & Chemicals Div., Carlisle Chemical Works, Inc.
Plastolein	Plasticizers for vinyls, cellulosics, and synthetics rubbers	Emery Industries, Inc.
Plastoline	Plastic lining	Heil Process Equipment
Plastolyn	Coated fleece back fabric	Columbus Coated Fabrics Corp.
Plastomoll	Softeners for lacquers and plastics	Badische Anilin- & Soda-Fabrik AG
Plastopal	Urea formaldehyde for lacquers, acid-resistant coating, and nitrocellulose lacquers	Badische Anilin- & Soda-Fabrik AG
Plastrong	Reinforced polyester premix molding compound	George Morrell Corp.
Plastylite	Vinyl phonograph record compound	Plastylite Corp.
Pla-Tank	Reinforced polyester for chemical process equipment	Haveg Industries, Inc.
Plax	Film, rod, bottles, and tubing	Plax Corp.
Plaxacrin	Plastic sheet	Plax Corp.
Plaxpak	Bottles, tubing, sheet, film, etc.	Plax Corp.
Plenco	Phenolic molding compounds; phenolic resins	Plastics Engineering Co.
Pleogen	Polyester resins	Mol-Rez Div., American Petrochemical Corp.
Plexicomb	Facing to core honeycomb	Plastex Laminates, Inc.
Plexiglas	Acrylic sheet, molding powder, etc.	Rohm & Haas Co.
Plicose	Polyethylene flat film and layflat tubing	Plicose Mfg. Corp.
Pliobond	Adhesives	Goodyear Tire & Rubber Co., Chemical Div.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Pliofilm	Rubber hydrochloride film	The Goodyear Tire & Rubber Co.
Plioflex rubber	Butadiene/styrene	Goodyear Tire & Rubber Co., Chemical Div.
Plioglas	Vinyl-coated glass cloth	Flexfirm Products
Pliogrip	Rubber-base adhesives	The Goodyear Tire & Rubber Co.
Pliolite	Styrene/butadiene rubber reinforcing resins; styrene/butadiene coating resins	The Goodyear Tire & Rubber Co.
Pliolite latex	Butadiene/styrene	Goodyear Tire & Rubber Co.
Pliotac	Rubber-base adhesives	The Goodyear Tire & Rubber Co.
Pliothene	Color compounds	Westchester Plastics, Inc.
Plio-Tuf	Styrene copolymer high impact resins	The Goodyear Tire & Rubber Co.
Pliovic	Vinyl chloride resins	Goodyear Tire & Rubber Co.
Pliovic latex	Vinyl chloride copolymer	Goodyear Tire & Rubber Co.
Plumb-O-Sil	Heat stabilizers for translucent and highly colored vinyl	National Lead Co.
Pluracol P Diols	Polypropylene adducts of varying molecular weights	Wyandotte Chemicals Corp.
Pluracol TP Polyols	Polyether triols which are polyoxypropylene derivatives of trimethylolpropane	Wyandotte Chemicals Corp.
Pluronic Polyols	A series of block polymer polyether diols derived from propylene and ethylene oxides	Wyandotte Chemicals Corp.
Plyacein	Protein adhesives	Reichhold Chemicals, Inc.
Plyamine	Urea-formaldehyde adhesives	Reichhold Chemicals, Inc.
Plyamul	Polyvinyl acetate adhesives	Reichhold Chemicals, Inc.
Plymaster	Adhesive-coated copper for printed circuits; adhesives in dry film form for rigid, semi-rigid, and flexible plastics and metals	Rubber & Asbestos Corp.
Plyophen	Phenol-formaldehyde resins, adhesives, and varnishes	Reichhold Chemicals, Inc.
Polectron	Vinyl carbazole molding compound; resin polymer	Antara Chemicals, Div. General Aniline & Film Corp.
Polesthan	Water-white, polyester embedments	Hanley Plastics Co.
Pollopas	Resin	Dynamit-Actien-Gelleschaft, Vormals Alfred Nobel & Co.
Polyac	Butyl rubber activator	E. I. du Pont de Nemours & Co., Inc.
Polybond	Adhesive	Polymer Industries, Inc.
Polybrand	Adhesive	Polymer Industries, Inc.
Polycast	Acrylic sheets	The Polycast Corp.
Polycast	Epoxy tooling	Poly Resins
Polycell	Cellulose casting resins	Poly Resins
Polycizer	Plasticizer	Harwick Standard Chemical Co.
Polyco	Resin emulsions	The Borden Chemical Co., Div. of the Borden Co.
Poly-eth	Polyethylene resin	Spencer Chemical Co.
Polyethylene Omni	Low-pressure polyethylene	Omni Products Corp.
Polyfilm	Polyethylene film	The Dow Chemical Co.
Polyfilm	Polyethylene film	Extruders, Inc.
Polyflex	Plastic sheet	Plax Corp.
Polyflexon	Molded polyethylene reinforced with inorganic fibers	Plymouth Industrial Products, Inc.
Poly-Flo	Polyvinyl-chloride precision parts	Electro-Chemical Products Corp.
Polyfoam	Polyurethane foam	The General Tire & Rubber Co.
Polygard	Rubber stabilizer	Naugatuck Chemical Div., United States Rubber Co.
Polygel	Aqueous and solvent gel structures (not polymerized) of resins, wax-like materials, and various non-metallic minerals	Chemical Industries, Unit of E. F. Van Winkle Co.
Polygum	Adhesive	Polymer Industries, Inc.
Polyken	Polyethylene film; polyethylene electrical tape; polyethylene protective tape coatings	The Kendall Co.
Poly-Kleen	Liquid cleanser	Schwartz Chemical Co., Inc.
Poly-Lease	Mold release agent	Plastics & Coal Chemicals Div., Allied Chemical Corp.
Poly-Lite	Plastic extrusions used as diffusers in lighted signs and displays	Sandee Mfg. Co.
Polylite	Polyester resins	Reichhold Chemicals, Inc.
Polymerin	Melamine-alkyd enamel	Interchemical Corp., Finishes Div.
Polymix	Dry-blended colored polyethylene	Gering Products, Inc.
Polyox	Water soluble resins	Union Carbide Chemicals Co., Div. of Union Carbide Corp.
Polypenco	Industrial plastics	The Polymer Corp.
Polyplastex	Decorative plastic sheeting and laminates (generally vinyl)	Polyplastex United, Inc.
Polyplax	Thermoformed packages made of polyethylene, polystyrene, and vinyl	Plaxall Inc.
Polyplex	Coatings for acrylics	Sullivan Chemicals Co.
Polyprene	Vinyl organosol enamel	Interchemical Corp., Finishes Div.
Poly-Pro	Polypropylene	Spencer Chemical Co.
Polyrez	Resins	Polyrez Co., Inc.
Polysol	Aqueous and solvent suspensions and micro dispersions of polyethylene, polystyrene, polyesters, epoxies, and non-metallic minerals	Chemical Industries, Unit of E. F. Van Winkle Co.
Polystrom-Omni	Polystyrene	Omni Products Corp.
Polystyrol of BASF	Polystyrene	Badische Anilin- & Soda-Fabrik AG
Poly Supra	Dry colorants for plastics	Krieger Color & Chemical Co., Inc.
Polytherm	Polystyrene for expandable expanded polystyrene	Omni Products Corp.
Polython	Polyethylene seamless thin-wall tubing and packaging bags; polyethylene film and sheeting	Poly Plastic Products, Inc.
Polytool	Polyester, epoxy, phenolic, and polyurethane tooling compounds	Reichhold Chemicals, Inc.
Polytreat	Polyethylene film	Extruders, Inc. (Sub. of The Dow Chemical Co.)
Ponsol	Dyes	E. I. du Pont de Nemours & Co., Inc.
Pontachrome	Dyes	E. I. du Pont de Nemours & Co., Inc.
Pontacyl	Dyes	E. I. du Pont de Nemours & Co., Inc.
Pontamine	Diazo dyes	E. I. du Pont de Nemours & Co., Inc.
Por-C-Lyn	Baked enamel finishes of exceptional hardness	Atlas Coatings Corp.
Portelvator	Portable elevating table	Hamilton Tool Co.
Portovent	Flexible hose	Flexaust Co.
Pre-Imp	Glass fiber loaded compound for molding	Flexfirm Products
Pres-a-ply	Pressure-sensitive gummed labels	Dennison Mfg. Co.
Pressure-Line	Flexible polyethylene pipe with built-in reinforcement	Skyline Industries; Skyline Plastic Pipe, Inc.; Skyline Plastic Molding, Inc.
Prestoflex	Vinyl film and sheeting	Presto Plastic Products Co., Inc.
Prestolene	Polyethylene film, tubing, and sheeting	J. P. Frank & Co., Inc.
Printon	Printed and decorated plastic material and films	Printon Corporation
Pro-fax	Polypropylene	Hercules Powder Co.
Propiofan	Polyvinylpropionate	Badische Anilin- & Soda-Fabrik AG
Protektinsul	Vapor barrier material; prefabricated polyvinyl duct covering	Miracle Adhesion Corp.
Protex	Zinc oxides	The New Jersey Zinc Co.
Protowrap	Plastics-coated paper	Kehr Products Co.
Provinite	Heat and light stabilizer for clear vinyl	National Lead Co.
Proxcote	Lacquer type coatings	Pyroxylin Products, Inc.
Proxmelt	Solid coatings and adhesives applied by heat	Pyroxylin Products, Inc.
Prox-mesh	Plastic reinforced with wire mesh	Pyroxylin Products, Inc.
Prox-Peel	Strippable coatings	Pyroxylin Products, Inc.
Pulva-Sizer	Granulating and pulverizing machines	Pulva Corp.
Pyralin	Cellulose nitrate	E. I. du Pont de Nemours & Co., Inc.
Pyro	Pyrometers	Pyrometer Instrument Co., Inc.
Pyrotex	Asbestos sheet and tapes	Raybestos-Manhattan, Inc., Reinforced Plastics Dept.

Q

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
QO	Furan chemicals and derivatives	The Quaker Oats Co., Chemicals Div.
Quakeral	Furfural	The Quaker Oats Co., Chemicals Div.
Quickset	Room temperature organic peroxide catalysts	U. S. Peroxygen Corp.
Quinorgo	Electrical insulations of purified asbestos with organic binder	Johns-Manville
Quinorgobord and Quinterrabord	Highly purified asbestos base sheet materials	Johns-Manville
Quinterra	Electrical insulations of 100% purified base sheet resin-treated	Johns-Manville

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Quinterrabord	Highly purified asbestos base sheet materials	Johns-Manville
Quso	Finely divided amorphous silica	Philadelphia Quartz Co.

R

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
R-B-H	Pigment dispersions in both chip and paste form	Interchemical Corp. Color & Chemicals Div.
RC	Plasticizers plastisols, co-monomers	Rubber Corp. of America
Rx	Sheets of phenolic resin-impregnated paperboards	Consolidated Paper Co.
Radialloy Tipped	Carbide tipped saw blades, router bits, special cutters, etc.	Radial Cutter Mfg. Corp.
Railite	Decorative laminates	Reiss Assoc., Inc.
Ramapo	Pigments	E. I. du Pont de Nemours & Co., Inc.
Randac	Thermosetting resins for impregnating, encapsulating, etc.	Mitchell Rand Mfg. Corp.
Rand Fiber	Resin depositor	Rand Development Corp.
Randfilm and Randflex	Vinyl sheeting (unsupported and supported)	Rand Rubber Co.
Raven	Carbon black	Columbian Carbon Co.
Rayaceta	Bleached sulfide pulp for cellulose acetate	Rayonier, Inc.
Raybrite	Reinforcement for plastics	Rayonier, Inc.
Rayette	Composition base sheet supported vinyl	Textileather Div., The General Tire & Rubber Co.
Raymix	Cut rayon fibers	Rayon Processing Co. of Rhode Island
Raytellics	Metallic particles for decorative filler for plastics	Rayon Processing Co. of Rhode Island
Readco	Mixing, kneading, or blending machines	Read Standard
Real-Ease	Silicone release compound	Borco Chemicals, Inc.
Realite	Decorative high-pressure melamine laminates	Reiss Assoc., Inc.
Reet	Vinyl and polyethylene film and sheeting	Ross & Roberts, Inc.
Reevon	Polyethylene filaments and fabrics	Reeves Bros., Inc.
Refrasil	High silica glass	H. I. Thompson Fiber Glass Co.
Re-New-Coat	Epoxy resin coating or resurfacing	Truscon Laboratories
Resilifoam	Foamed slab stock and foamed or fabricated shapes	Plastomer Corp.
Resilyte	Decorative plastic laminates	The Buckstaff Co.
Resimene	Urea and melamine resins	Monsanto Chemical Co.
Resinite	Thermoplastic resin in form of extruded tubing, tape, and shapes	Resinite Dept., Div. of The Borden Co.
Resinox	Phenolic resins and compounds	Monsanto Chemical Co.
Resloom	Textile resins (melamine and cyclic ethylene urea)	Monsanto Chemical Co.
Resmetal	Metallic patching paste (self-hardening solder)	The Borden Chemical Co.,
Resoflex R-296	Compatible, resinous, non-volatile, and non-migrating plasticizer for polyvinyl acetate	Cambridge Industries Co.
Resoform	Dyes and pigments for use in coloring resins and plastics	General Dyestuff Co. Div. of General Aniline & Film Corp.
Resorsabond	Resorcinol resins	American-Marietta Co., Adhesive, Resin & Chemical Div.
Respro	Vinyl film, sheeting, and coated fabrics	Bolta Products Div., The General Tire & Rubber Co.
Resproid	Vinyl film, sheeting, and coated fabrics	Bolta Products Div., The General Tire & Rubber Co.
Reswax	Synthetic wax-resin combination	The Borden Chemical Co.,
Resyn	Complete line of resin-base adhesives	National Starch Co.
Rexadhere	Primers and lacquers	Rexton Finishes, Inc.
Rexadur	Chlorinated rubber coatings	Rexton Finishes, Inc.
Rexalator	Chemical catalyst	Rexton Finishes, Inc.
Rexatherm, Rexclad, Rexlance	Enamels	Rexton Finishes, Inc.
Reynofoam-P	Polyurethane foams	Reynolds Chemical Products Co.
Reynofoam-V	Vinyl chloride foams	Reynolds Chemical Products Co.
Reynosol	Plastisols and organosols	Reynolds Chemical Products Co.
Rez-n-bond	Acrylic and styrene cement	Schwartz Chemical Co.
Rez-n-dye	Dyes for plastics	Schwartz Chemical Co.
Rez-N-Lac	Lacquers for all plastics	Schwartz Chemical Co. Inc.
Rez-N-Polish	Powder cleaner and anti-static	Schwartz Chemical Co. Inc.
Rigicast	Cast plastic	Heil Process Equipment Corp.
Rigidene	Polyethylene	Heil Process Equipment Corp.
Rigidon	Glass-reinforced plastic	Heil Process Equipment Corp.
Rigidsol	Rigid plastisol	Watson-Standard Co.
Rigivin	Rigid vinyl	Heil Process Equipment Corp.
Rila	Fluorescent pigments	Rhode Island Laboratories, Inc.
Rincontrol	Wrinkle enamels	Interchemical Corp., Finishes Div.
Rippolite	Fibrous glass reinforced laminate sheets	Rippolite Plastic Products, Inc.
Rolease	Silicone rubber-covered roll for plastics processing applications	Stowe-Woodward, Inc.
Roller Patent	Vinyl material with a patent finish, in roller form	Sommers Plastic Products Co.
Rona	Pearl essence and pearlescent pigments	Rona Laboratories, Inc.
Rontex	Plastic sealing compound for textile materials	Flexfirm Products
Roofmate	Expanded polystyrene	The Dow Chemical Co.
Roracyl	Dyes	E. I. du Pont de Nemours & Co., Inc.
Rosite	Inorganic and organic molded electrical insulating materials	Rostone Corp.
Rotalin	Dyes	E. I. du Pont de Nemours & Co., Inc.
Rotamill	Semi-automatic rotary milling machines	Dowding & Doll, Ltd.
Rotoshere L	Portable round knife cutting machine	H. Maimin Co., Inc.
Rovcloth	Woven roving	Fiber Glass Industries, Inc.
Rovmat	Unidirectional mechanically bonded glass mat-	Fiber Glass Industries, Inc.
Royalite	Blend of synthetic rubber and thermoplastic resin (A-B-S polymer blend)	United States Rubber Co.
Royal Master	Centerless grinding machine	Royal Master, Inc.
Rucoam	Vinyl film and sheeting	Rubber Corp. of America
Ruddflex	Vinyl sheeting & film; also butyrate, fluorocarbons, styrene copolymers, etc., silicones; laminates; vinyl-coated cloth	Rudd Plastic Fabrics Corp.
Rulon	Modified flurocarbon for high temperature bearings	Dixon Corp.
Ryertex Omicron PVC	Polyvinylchloride	Joseph T. Ryerson & Son

S

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
S.C.A.E.	Electronic apparatus for treating polyethylene film; welding and cutting machine; photocell controlled	S.C.A.E., Baccio da Montelupo
Safety-Sight	Fluorescent products	Lawter Chemicals, Inc.
Saflex	Polyvinyl butyral film	Monsanto Chemical Co.
Safrella	Sassafras ordorant	Fritzsche Bros., Inc.
Safe-T-Dek	Alkyd base non-slip coating for floors	Truscon Laboratories
Samson Extra	Steel for plastic molds	The Carpenter Steel Co.
San-D-Lite	Polyethylene sheet materials	Sandee Mfg. Co.
Sandt	Die presses	Atlas-Sandt Corp.
Saraloy 400	Vinylidene chloride elastic sheeting	The Dow Chemical Co.
Saran-O-Lam	Printed and laminated, saran films, saran casing, etc.	Printon Corp.
Saran & Saran Wrap	Vinylidene chloride copolymers	The Dow Chemical Co.
Sarcotrol	Mold temperature controller	Sarco Co., Inc.
Satinesque & Satinglo	Vinyl coated fabrics	Columbus Coated Products Corp.
Satusply	Reinforced-polyester laminate	United States Rubber Co.
Scalperator	Machine for separating mechanically and pneumatically	Hart-Carter Co.
Screen-O-Printer	Silk screening equipment	Screen-O-Printer Mfg. Co.
Scriptite	Paper finishes	Monsanto Chemical Co.
Scorbord	Expanded polystyrene	The Dow Chemical Co.
Scotchply Brand Reinforced Plastic	Continuous, non-woven filament orientation	Minnesota Mining & Mfg. Co.
Sealcast	Potting and casting compounds	Minneapolis Honeywell Regulator Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Sealdbin & Sealdtank	Flexible, collapsible container of multi-ply rubbercoated cord fabric for shipping of corrosive liquids and various types of dry flowable solids	United States Rubber Co.
Sealerine	Concrete sealer	Customs Coatings Co.
Sealfoam	Foam-in-place compounds	Minneapolis Honeywell Regulator Co.
Sealine	Hand-operated portable heat sealer	Sealine Mfg. Corp.
Seal-peel	Hot melt strippable coatings	Seal-Peel, Inc.
Sealset	Activators and hardeners	Minneapolis Honeywell Regulator Co.
Sealweld	Adhesives	Minneapolis Honeywell Regulator Co.
Sealz	Rubberized bitumens	Naugatuck Chemical Div., United States Rubber Co.
Seamco	Styrene molding material	Seamco Chemical Co.
Seilon	Vinyl, styrene, and polyethylene rolls and sheets for vacuum forming	Seiberling Rubber Co., Plastics Div.
Selectrol	Automatic checkweigher	The Exact Weight Scale Co.
Servospeed	Variable-speed motor drive systems	Electro-Devices, Inc.
Sevron	Dyes	E. I. du Pont de Nemours & Co., Inc.
Shelblast	Soft grit blasting material for cleaning of molds	Agrashell, Inc.
Shellene	Packing bags or sacks made of polyethylene	Flexible Packaging Div., Continental Can Co.
Shell-pli	Laminated products (cellulose sheeting combined with other products)	Flexible Packaging Div., Continental Can Co.
Sicofane	Regenerated cellulose film	Mazzucchelli Celluloide S.p.A.
Sicalene	Polyethylene sheets	Mazzucchelli Celluloide S.p.A.
Sicalit	Cellulose acetate molding powder	Mazzucchelli Celluloide S.p.A.
Sicaloid	Cellulose acetate sheets	Mazzucchelli Celluloide S.p.A.
Sicofoil	Cellulose acetate and triacetate film	Mazzucchelli Celluloide S.p.A.
Sicovinile	Vinyl and vinyl copolymer sheets	Mazzucchelli Celluloide S.p.A.
Sierra	Phenolic and urea forms, plates, shapes, and devices	Sierra Electric Corp.
Sierracin	Cast transparent polyester sheet	The Sierracin Corp.
Sierracote	Transparent conductive coating	The Sierracin Corp.
Sierralite	Phosphorous and luminous compositions and devices	Sierra Electric Corp.
Sierratex	Colored coatings	Sierra Electric Corp.
Silastic	Silicone rubber	Dow Corning Corp.
Silcobest	Laminated glass cloth slot wedges	Silicone Insulation, Inc.
Silvacel	Pulp molding compound	Weyerhauser Sales Co., Special Products Div.
Silvacon	Extender and filler for vaious molding compounds and casting resins	Weyerhauser Sales Co., Special Products Div.
Silvacote	Vacuum metalized finish	The Eyelet Specialty Co.
Silvaloy	Moldable wood fibers	Weyerhauser Sales Co., Special Products Div.
Silvatrim	Metalized plastic strip	Glass Laboratories, Inc.
Sirco	Nut shell flour used as fillers	Bernard Sirotta Co.
Sircoblast	Ground nut shell pellets for soft grit blast-cleaning and deflashing of molded plastics products	Bernard Sirotta Co.
Slip-Eze	Slip agent for polyethylene	Fine Organics, Inc.
Smooth-on	Iron cements; polysulfide flexible mold compounds	Smooth-On Mfg. Co.
Sno-pak	Resin foam for mounting and preserving cut flowers	Colton Chemical Co.
Sobolicate	Specially treated tumbling granular	Lupoline Automatic Polishing Equipment Corp.
Solfast	Colorants (red and blue)	The Sherwin Williams Co.
Solka-Floc	Finely-divided purified cellulose	Brown Co.
Solox	Denatured alcohol solvent	U. S. Industrial Chemicals Co., Div. National Distillers & Chemical Corp.
Solozone	Sodium peroxide	E. I. du Pont de Nemours & Co., Inc.
Solvenon	Dimethylacetate for solvents and thinner for lacquers	Badische Anilin- & Soda-Fabrik AG
Solvic	Polyvinylchloride resins and vinyl copolymers	Solvic S.A.
Son Blaster	Ultrasonic vibrators; cleaning machines for buffing compounds, etc.	The Narda Uutrasonics Corp.
Sonite	Non-metallic epoxy formulations; repair kits and hardeners	Smooth-On Mfg. Co.
Sonogen	Ultrasonic generators and transducers	Branson Ultrasonic Corp.
Spac	Anti-static agent	S. M. Edison Chemical
Span	Emulsifying agent	Atlas Powder Co.
Spectro-Chrome	Metallic insert extrusion	Schwab Plastics Corp.
Speed Clamps, Speed Clips, Speed Grips, Speed Nuts	Fasteners	Tinnerman Products, Inc.
Speedmaster	Variable speed transmission	The DoAll Co.
Speed-Rex	Epoxy coating for metal and machinery	Truscon Laboratories
Spen-Amm	Anhydrous ammonia	Spencer Chemical Co.
Spencer nylon	Nylon resin	Spencer Chemical Co.
Spensol	Nitrogen solutions	Spencer Chemical Co.
Spiral tubing	Spiral wound tubing	Continental-Diamond Fibre Corp.
Spirod & Spiroyl	Extruding machine	John Royle & Sons
Spiralloy	Filament-wound, fibrous glass-epoxy cylinders, pressure vessels, nose cones, rocket cases, and other special high integrity structures	Young Development Div., Hercules Powder Co., Inc., Rocky Hill, N. J.
Spraylat	Water base strippable protective coatings	Spraylat Corp.
Sprits	Mold release	Sprits
Stabelan	Stabilizers	Nopco Chemical Co.
Staflex	Plasticizers and stabilizers	Deecy Products Co.
Stalpic	Phenol formaldehyde resin coatings	A. Gusmer, Inc.
Standard	Power and gravity conveyors	Standard Conveyor Co.
Standard weytex	Hardboard	Weyerhauser Sales Co.
Stan-Tone	Colors	Harwick Standard Chemical Co.
Stat-Eze	Non-discoloring anti-static	Fine Organics, Inc.
Statex	Carbon black	Columbian Carbon Co.
Statikil	Anti-static chemicals	The J. E. Doyle Co.
Stearite	Hydrogenated stearic acid	Witco Chemical Co.
Stentor	Steel for plastic molds	The Carpenter Steel Co.
Sterico	Temperature control equipment and devices	Sterling, Inc.
Sterilkote	Vinyl plastisols and organosols; vinyl and epoxy industrial finishings	Bradley & Vrooman Co.
Sterling	Furnace and thermal carbon blacks	Godfrey L. Cabot, Inc.
Stix	Vinyl adhesive	Firestone Plastics Co.
Stixso	Silicate adhesive	Philadelphia Quartz Co.
Stonite	Protective coatings	Stoner-Mudge Co.
S-T-R-E-T-C-H	Polyethylene color concentrate	Gering Products, Inc.
Stripomatik	Portable round knife cutting machine	H. Maimin Co., Inc.
Stycast	Casting resins	Emerson & Cuming, Inc.
Stylour	Flocked polystyrene sheet	The Gilman Brothers Co.
Stylplast	Urea-formaldehyde compounds (molding)	American Viscose Corp.
Stymer	Vinyl resin and styrene copolymer textile sizes	Monsanto Chemical Co.
Stypol	Polyester resin	H. H. Robertson Co.
Styresol	Styrenated alkyd resins	Reichhold Chemicals, Inc.
Styretex	Styrenated alkyd resins	Jones-Dabney Co.
Styrocel	Expandable polystyrene beads; expanded polystyrene board	Styrene Products, Ltd.
Styrofan	Plastics dispersions for impregnating and coatings	Badische Anilin- & Soda-Fabrik AG
Styroflex	Oriented polystyrene film	Natvar Corp.
Styrofoam	Expandable polystyrene	Dow Chemical Co.
Styromix	Dry blended color premixed styrene	Gering Products, Inc.
Styron	Polystyrene	Dow Chemical Co.
Styropor	Expendable polystyrene	Badische Anilin- & Soda-Fabrik AG
Styroseal	Adhesive for bonding Styrofoam	Narmco Resins & Coatings Co.
Sulfanthrene	Dyes	E. I. du Pont de Nemours & Co., Inc.
Sulfogene	Dyes	E. I. du Pont de Nemours & Co., Inc.
Sullvac	Thermoplastic sheeting (rigid and semi-rigid)	O'Sullivan Rubber Corp.
Sullvac 200	Rigid acrylonitrile-butadiene-styrene sheeting for vacuum forming	O'Sullivan Rubber Corp.
Sullvac 300	Semi-rigid terpolymer sheeting for vacuum forming	O'Sullivan Rubber Corp.
Sullvyne	Plasticized PVC sheeting	O'Sullivan Rubber Corp.
Sullvyne-Clad	Vinyl sheeting laminated to metal	O'Sullivan Rubber Corp.
Sunform	Flexible sheet material made of glass fibers impregnated with a thermosetting resin for use in the fabrication of laminated structures	Electro-Technical Products, Div. Sun Chemical Corp.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Superba	Carbon black	Columbian Carbon Co.
Super-beckacite	Phenolic resins	Reichhold Chemicals, Inc.
Super-beckamine	Melamine-formaldehyde resins	Reichhold Chemicals, Inc.
Super-beckosol	Isophthalic acid alkyd resins	Reichhold Chemicals, Inc.
Supercarbovar	Medium color channel carbon blacks	Godfrey L. Cabot, Inc.
Super Dylan	High-density polyethylene	Koppers Co., Inc.
Superlith	Pure zinc sulphide and concentrated lithopone	C. J. Osborn Co.
Super Modulene	Linear polyethylene (resin and molding compound)	H. Muehlstein & Co., Inc.
Super-Multifex	Precipitated calcium carbonate	Diamond-Alkali Co.
Super-por-seal	Silicone base	Truscon Laboratories
Super Samson	Steel for plastic molds	The Carpenter Steel Co.
Superior	Sheet wax for plastic die work (with or without pressure-sensitive adhesive applied)	The P.M.S. Co.
Supertone	Urea-formaldehyde molding powder	Lacrinoid Products, Ltd.
Super-tourex	Extruded thermoplastics	Waljohn Plastics, Inc.
Supervac	High vacuum pump	Central Scientific Co.
Supramica	Ceramoplastics for electronic insulation	Mycalex Corp. of America
Suprathen	High-pressure polyethylene film	Kalle & Co., A.G.
Supreme	Choppers, crushers, pulverizers	Franklin P. Miller & Son, Inc.
Suprether	Polyether foam	Wm. T. Burnett & Co.
Supronyl	Superpolyamide film	Kalle & Co., A.G.
Surfex	Precipitated calcium carbonate (resin-coated)	Diamond-Alkali Co.
Surfynol	Organic surface active agents	Air Reduction Chemical Co.
Suspenso	Precipitated calcium carbonate (resin coated)	Diamond Alkali Co.
Swanette	Vinyl film and sheeting	Harte & Co., Inc.
Swirlustre	Patterned pearlescent acrylic sheets and blanks	U. S. Plastic Products Corp.
Sylkyd	Silicone alkyd resin	Dow Corning Corp .
Syloy	Reinforced fibrous glass	The General Tire & Rubber Co.
Sylplast	Urea-formaldehyde molding compounds	Sylvan Plastics, Inc.
Syncast	Polymerizable casting materials (liquid and solid)	Synco Resins, Inc.
Synco	Synthetic resins and adhesives	Synco Resins, Inc.
Syncoat	Synthetic resins of the air-dry and heat-reactive type	Synco Resins, Inc.
Synsize	Liquid urea-formaldehyde resins	Synco Resins, Inc.
Synskyn	Vinyl coated non-woven fibrous glass mat	Polyplastex United, Inc.
Syntex	Alkyd resins	Jones-Dabney Co.
Synthamica	Synthetic mica	Mycalex Corp. of America
Synthane	Laminated plastic products	Synthane Corp.
Synthe-copal	Ester gums and ester gum solutions	Reichhold Chemicals, Inc.
Synthe-mul	Alkyd emulsions	Reichhold Chemicals, Inc.
Syn-U-Tex	Urea-formaldehyde resins	Jones-Dabney Co.
Synvaren	Liquid phenol-formaldehyde resins	Synvar Corp.
Synvarite	Solid urea-formaldehyde and phenol-formaldehyde resins (powder, granules, and lump form)	Synvar Corp.
Synvarol	Liquid urea-formaldehyde resins	Synvar Corp.

T

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
T.E.C.	Vertical extruder adaptable to two-color operations	Thermoplastic Equipment Corp.
TME	Trimethylolethane	Heyden Newport Chemical Corp.
T.M.I.	Physical testers	Testing Machines, Inc.
TMP	Trimethylolpropane	Heyden Newport Chemical Corp.
Tackmaster	Pressure-sensitive adhesives in dry film form	Rubber & Asbestos Corp.
Tan-O-lite	Vinyl-coated fabric	Columbia Mills, Inc.
Tan-o-tex	Pyroxylin-coated fabric	Columbia Mills, Inc.
Tap-Lok	Self-tapping, self-locking internally and externally threaded bushing	Groov-Pin Corp.
Techangle	Barrel finishing media	Techline Div., Wheelabrator Corp.
Techline	Barrel finishing equipment	Techline Div., Wheelabrator Corp.
Technoscent	Heat resistant plastic odorant	Fritzsche Bros., Inc.
Teflon	Fluorocarbon (resin, fiber, resin finishes, and resin wire enamels)	E. I. du Pont de Nemours & Co., Inc.
Tegit	Phenolic cold mold material	Garfield Mfg. Co.
Telenduron	Bituminous moulding compound	British Moulded Plastics Ltd.
Temco	Winding equipment	Sealol Corp.
Tempered weytex	Hardboard	Weyerhauser Sales Co.
Tenite	Cellulose acetate, cellulose acetate butyrate, polyethylene, cellulose acetate propionate, polypropylene	Eastman Chemical Products, Inc.
Tenlo	Plastisol viscosity depressants	Nopco Chemical Co.
Tensilkut	High-speed contoured milling machine	Sieburg Industries, Inc.
Tensilite	Paper base laminates	The J. P. Lewis Co.
Tepidone	Rubber accelerator	E. I. du Pont de Nemours & Co., Inc.
Teracol	Polyalkylene	E. I. du Pont de Nemours & Co., Inc.
Terek	Cellulose-coated fabrics	Athol Mfg. Co.
Terekan	Cellulose-coated paper	Athol Mfg. Co.
Terezon	Vinyl-coated paper	Athol Mfg. Co.
Tergitol	Water soluble resins	Union Carbide Chemicals Co., Div. of Union Carbide Corp.
Terson	Vinyl-coated fabrics	Athol Mfg. Co.
Teslar	Polyvinyl fluoride film	E. I. du Pont de Nemours & Co., Inc.
Tetralin	Solvent	E. I. du Pont de Nemours & Co., Inc.
Tetrone	Rubber accelerator	E. I. du Pont de Nemours & Co., Inc.
Tetronic Polyols	A series of block polymer polyether tetraols which are polyoxypropylene — polyoxyethylene derivatives of ethylene diamine	Wyandotte Chemical Corp.
Texol	Plastic simulated to resemble leather	Farrington Texol Corp.
Texolex	Plastic-coated papers	Farrington Texol Corp.
Textileather	Pyroxylin-coated fabric	Textileather Div., General Tire & Rubber Co.
Textiloid	Pyroxylin coated resin bonded composition (paper backed)	Textileather Div., General Tire & Rubber Co.
Textolite	High-pressure laminates; electrical insulation sheets, rods, and tubes	General Electric Co.
Textrol	Wrinkle enamels	Rexton Finishes, Inc.
Therimage	Transfer labeling	Dennison Mfg. Co.
Therma Fin	Extruders	Davis-Standard Div., Franklin Research Corp.
Thermaflow	Reinforced polyester molding compounds	Atlas Powder Co.
Thermatron	High-frequency heat sealing and preheating equipment	Thermatron Co., The, Div. of Willcox & Gibbs Sewing Machine Co.
Thermatube	Tubular type electric heaters	Thermel, Inc.
Thermex	High-frequency preheating equipment	The Girdler Co., Thermex Div., A Div. of National Cylinder Gas Co.
Thermo-Check	Pipe insulation (expanded styrene)	Schwab Plastics Corp.
Thermo-Cote	Hot melt protective strippable coatings	Bischoff Chemical Corp.
Thermodip	Hot melt CMPD strippable specification C-149—Type 11	Eronel Industries
Thermo-Dynamic	Steam traps	Sarco Co., Inc.
Thermoflex	Rubber antioxidants	E. I. du Pont de Nemours & Co., Inc.
Thermo-Kote	Strippable protective coatings	Bischoff Chemical Corp.
Thermolator	Mold temperature control	Industrial Mfg. Corp.
Thermolite	Stabilizers	Metal & Thermit Corp.
Thermomat	Radiant panel heater for industrial applications	Thermomat Co.
Thermoscent	Deodorant for plastics	Fritzsche Bros., Inc.
THFA	Tetrahydrofurfuryl alcohol	The Quaker Oats Co., Chemicals Dept.
Thinflex	Masking tape	Mystik Adhesive Products Inc.
Thiokol	Sulfur containing plastic material	Thiokol Chemical Corp.
Thiokol	Class 1: polysulfide synthetic rubbers organic sulfur-containing material; Class 6: (chemicals) polysulfide polymers, sulfur compounds, plasticizers	Thiokol Chemical Corp.
Thionex	Rubber accelerator	E. I. du Pont de Nemours & Co., Inc.
Thixagel	Organic and inorganic gel structures of resins and plasticizers for viscosity control and gel coating	Chemical Industries, Unit of E. F. Van Winkle Co.
Thor	Resin emulsions	The Borden Chemical Co.,
Thoro Blender	Dry blender	The Patterson Foundry & Machine Co.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Timken	Tapered roller bearings	Timken Roller Bearing Co., The
Tinopal PCRP	Optical whitener for all types of plastics	J. R. Geigy S.A.
Ti-Pure	Titanium dioxides	E. I. du Pont de Nemours & Co., Inc.
Titanox	White colorants (pigments) for plastics	Titanium Pigment Corp.
Tolex	Fabric-supported vinyl	Textileather Div., General Tire & Rubber Co.
Tolon	Unsupported vinyl sheeting	Textileather Div., General Tire & Rubber Co.
Toolplastik	Plastic materials for tooling	Rezolin, Inc.
Tourex	Extruded thermoplastics	Waljohn Plastics, Inc.
Tower	Vinyl films and sheetings	Canadian General Tower Ltd.
Toxilic	Maleic acid and anhydride	National Aniline Div., Allied Chemical & Dye Corp.
Treadmaster	Industrial adhesives	Rubber & Asbestos Corp.
Trevarno	Phenolic, polyester, epoxy, silicone resin, glass-impregnated cloth	Coast Mfg. & Supply Co.
Triclene	Trichlorethylene	E. I. du Pont de Nemours & Co., Inc.
Trimal	Vulcanizing agent for chlorosulfonated polyethylene; highly basic stabilizer for vinyl	National Lead Co.
Tripentek	Tripentaerythritol technical	Heyden Newport Chemical Corp.
Triplax	Molded trifluorochloroethylene	Plax Corp.
Trogamid	Polyamide bars	Dynamit-Actien-Gesellschaft
Tropiglas	Reinforced plastic panels	Russell Reinforced Plastics Corp.
Trostel Vulkollan	Cast urethane elastomer	Albert Trostel & Sons Co.
Trovidur	Hard PVC blocks, sheets, etc.	Dynamit-Actien-Gesellschaft
Troytuf	Non-woven synthetic fiber reinforcing and surfacing mat	Troy Blanket Mills
Tru-Cast	Fabricating of cavities and/or cores by pressure casting of non-ferrous metals	Manco Products, Inc.
Truflex	Plasticizers	Thompson Chemical Co.
Trulon	Vinyl chloride polymers	Thompson Chemical Co.
Trycite	Polystyrene sheet film	The Dow Chemical Co.
T.S.I.	Teflon rod	Tri-Point Plastics, Inc.
Tuf-Cote	Vinyl-coated upholstery fabrics	Canadian General Tower, Ltd.
Tuff-Lite	Plastic pipe, etc.	Industrial Plastic Co.
Tuft-Tite	Electronically-quilted plastic	The Barr Corp.
Tulox	Tubing (cellulose acetate butyrate); extruded transparent sleeves	Extruded Plastics, Inc.
Tumblast	Batch-type mechanical deflashing machines	Wheelabrator Corp.
Tungseal	Penetrating phenolic sealer	McCloskey Varnish Co.
Turbo-Dryer	Continuous vertical dryers for plastics and other solids	Wyssmont Co., Inc.
Turon	Lightweight supported vinyl fabric	Textileather Div., General Tire & Rubber Co.
Tween	Emulsifiers	Atlas Powder Co.
Twinweld	Epoxy adhesive, filler, solder	Schramm Fiberglass Products, Inc.
Tybon	All resinous products	Booty Resineers, Div. of American Marietta Co.
Tygobond-30	Adhesive	U.S. Stoneware Co.
Tygon	Plastic tubing, coatings, sheet	U.S. Stoneware Co.
Tygoweld	Adhesive	U.S. Stoneware Co.
Tylene	Tooling plastics	Tylene Plastics, Inc.
Tynex	Nylon bristles and filaments	E. I. du Pont de Nemours & Co., Inc.
Ty Ply	Rubber and metal bonding agents	Marbon Chem., Div. of Borg-Warner Corp.
Tyril	Acrylonitrile copolymer	The Dow Chemical Co.

U

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Ubabond	Acrylonitrile solvent cement	UBS Chemical Corp.
Ubatol	Modified polystyrene emulsion	UBS Chemical Corp.
Ultracal	Gypsum cements (mold material)	United States Gypsum Co.
Ultramid	Polyamide	Badische Anilin- & Soda-Fabrik AG
Ultrapas	Melamine resin	Dynamit-Actien-Gesellschaft
Ultron	Vinyl film	Monsanto Chemical Co.
Unex Jet Plastic Molder	Hand-operated injection molding machine	Unex Laboratories
Unibac	Special polymer for fabric backing	UBS Chemical Corp.
Unicel	Blowing agent	E. I. du Pont de Nemours & Co., Inc.
Unichrome	Coatings	Metal & Thermit Co.
Unicolor	Color compounds	Westchester Plastics, Inc.
Unicomb	Coating process to honeycomb	Plastex Laminates, Inc.
Uni-Crest	Expanded polystyrene	Uni-Crest Div., United Cork Companies
Unifab	Woven glass fabrics	Ferro Corp., Fiber Glass Div.
Unifoam	Flexible urethane foam	Wm. T. Burnett & Co., Inc.
Uniformat	Fibrous glass in mat form	Ferro Corp., Fiber Glass Div.
Uniglass	Woven glass fabric	United Merchants Industrial Fabrics
Uni-Lok	Uni-directional woven roving fabric	Bean Fiber Glass Div., D.D. Bean & Sons Co.
Union Carbide	Polyethylene, vinyl, phenolic, and polystyrene, plastics resins and compounds	Union Carbide International Co., Div. Union Carbide Corp
Unirove	Woven fibrous glass roving	Ferro Corp., Fiber Glass Div.
US-Kon	Flexible electric rubber heating blankets for prewarming or forming plastics	United States Rubber Co.
U.S. Naugahyde	Rubber- or vinyl-coated, lightweight fabric	United States Rubber Co.
Unitite	Control valves	Hanna Engineering Works
Urac	Urea adhesive resins	American Cyanamid Co.
Uramol	Urea-formaldehyde molding compound	Gordon Chemicals, Inc.
Urecoll	Binder for wastewood board & articles molded of such	Badische Anilin- & Soda-Fabrik AG
Urecoll F	Urea-formaldehyde resins	Badische Anilin- & Soda-Fabrik AG
Urefoam	Expanded plastic	Atlas Mineral Products Co.
U.S.I. Isosebacic	Mixture of isomers of sebacic acid	U.S. Industrial Chemicals Co., Div. National Distillers & Chemical Corp.
Uvinul	Ultra-violet light absorber; light stabilizer	Antara Chemicals, Div., General Aniline & Film Corp.

V

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
VA-7	Vulcanizing agents	Thiokol Chemical Corp.
Vacform	Vacuum forming machine for thermoplastic sheet	Emhart Mfg. Co. Standard-Knapp Div.
Vacuvator	Equipment for making Kirksite mold cavities; also pattern and model making	Guy P. Harvey & Son Corp.
Valite	Phenolic resins, phenolic moldings, thermoplastic resins	Valite, Div. of Valentine Sugars, Inc.
Value	Vinyl sheeting (unsupported and supported)	Rand Rubber Co.
Varimatic	Drilling machine	The Hamilton Tool Co.
Varlac	High-gloss varnish type finish in rapid drying	Atlas Coatings Corp.
VC-V	Vinyl cement	Schwartz Chemical Co.
Vega	Steel for plastic molds	The Carpenter Steel Co.
Velbac	Napped sheeting and vinyl laminate	Velveray Corp.
Velbex	Flexible vinyl	BX Plastics, Ltd.
Velon	Vinyl film, sheeting, monofilaments, and multifilament yarns	Firestone Plastics Co.
Velvetex	Film and sheeting laminate	Velveray Corp.
Versa Cutter	Precision cut-off machines	Foster & Allen, Inc.
Verisoft	Pigments	H. Kohnstamm & Co., Inc.
Versamid	Polyamide resins	General Mills Inc., Chemical Div.
Versilan	Vinyl upholstery material	The Landers Corp
Vibrafoam	Cellular urethane sheet or molded goods	United States Rubber Co.
Vibrathane	Prepolymer casting resin; urethane elastomer	United States Rubber Co.
Vibrin	Polyester resins	Naugatuck Chemical Div., United States Rubber Co.
Vichrome	Vinyl enamels	Interchemical Corp.
Vicra-Lite	Vinyl-coated products	L. E. Carpenter & Co.
Vicrtex	Vinyl coated and impregnated products	L. E. Carpenter & Co.
Videne	Polyester film	Goodyear Tire & Rubber Co.
Vidigage	Ultrasonic thickness testers	Branson Instruments, Inc.
Vinac	Polyvinyl acetate emulsions	Colton Chemical Co., Div. Air Reduction Co., Inc.
Vinalast	Supported and unsupported plastic film and sheeting in various finishes (embossed. printed, plain, etc.)	Marbek Inc.
Vinaplas-Lac	Vinyl lacquer	Schwartz Chemical Co., Inc.
Vinaplex	Coatings for vinyls	Sullivan Chemicals Div.
Vinaquilt	Quilted plastic fabrics	Marbek, Inc.

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Vinoflex	Polyvinylchloride	Badische Anilin- & Soda-Fabrik AG
Vinol	Polyvinyl alcohol	Colton Chemical Co., Div. Air Reduction Co., Inc.
Vinrex	Vinyl coatings	Rexton Finishes, Inc.
Vin-So-Lite	Foamed vinyl open-cell or unicellular	Foam King, Inc.
Vinylac	Organic tackifiers	The Borden Chemical Company
Vinylite	Calendered vinyl film sheeting and elastomeric vinyl molding and extrusion compounds (for domestic market)	Canadian Resins & Chemicals Ltd.
Vinylite	Coated paper	Union Carbide Plastics Co., Div. of Union Carbide Corp.
Vinylum	Aluminum dispersion	Argus Chemical Corp.
Violite	Luminescent pigments	Rhode Island Laboratories, Inc.
Vipla	Polyvinyl chloride-vinyl acetate copolymer	Chemore Corp.
Viscotrola	Thickening agents for plastisols, paints, etc.	Ferro Chemical Corp.
Viton	Synthetic rubbers	E. I. du Pont de Nemours & Co., Inc.
Vitron	Glass fiber roving	L O F Glass Fibers Co.
Vitroplast	Polyester cement	Atlas Mineral Products Co.
Vuepak	Cellulose acetate film	Monsanto Chemical Co.
Vulcan	Oil furnace carbon blacks	Godfrey L. Cabot, Inc.
Vulcoid	Resin impregnated fiber	Continental Diamond Fibre Corp.
Vulkollan	Cast urethane elastomer	Mobay Chemical Co.
Vultac	Alkyl pheno sulfide vulcanizing agents	Pennsalt Chemicals Corp.
Vycanac	Calendered vinyl film and sheeting and elastomeric vinyl molding and extrusion compounds (for export market)	Canadian Resins & Chemicals, Ltd.
Vygen	Polyvinyl chloride resin	General Tire & Rubber Co., Chemical Div.
Vynavue	Clear vinyl chloride sheeting	Fabric Leather Corp.
Vyn-Eze	Slip agents for vinyls	Fine Organics, Inc.

W

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
W-S Hydraulic	Hydraulic machinery and equipment	Watson-Stillman Press Div., Farrel-Birmingham Co., Inc.
Wabash hydraulic laboratory presses	For laminating, compression molding, testing	Wabash Metal Products Co.
Wallfab	Polyester paper flexible flat laminate	M. C. Gill Corp.
Wallpol	Polyvinyl acetate emulsions	Reichhold Chemicals, Inc.
Wall-Tex	Oil-coated fabric for wall covering	Columbus Coated Fabrics Corp.
Wasco Acrylite	Acrylic structural panels with decorative embedments	Wasco Products, Inc.
Wascofilm	Polyethylene moisture barriers in rolls	Wasco Products, Inc.
Wascoseal	Vinyl moisture barrier	Wasco Products, Inc.
Wataseal	Vinyl film & sheeting	Harte & Co., Inc.
Waterground Mica	Finely ground mica	The English Mica Co.
Water Clear	Vinyl roller polished on both sides	S. I. Jacobson Mfg. Co.
Waterez	Alkali-soluble, hard alkyd resins	Reichhold Chemicals Inc.
Watson-Stillman	Hydraulic machinery and equipment	Watson-Stillman Press Div., Farrel-Birmingham Co., Inc.
Wearon	Extruded plastic	Maynard Plastics Co.
Weather-ometer	Testing apparatus, accelerated weathering	Atlas Electric Devices Co.
Weblon	Synthetic (nylon, Dacron, etc.) and fibrous glass reinforced vinyl film	Weblon, Inc.
Weld Fast	Thermosetting cement-filled epoxy	The Fibercast Corp.
Westminster	Injection molding machines for experimental work	Dowding & Doll, Ltd.
Wetfast K	Special glass fabrics designed for boat and tooling applications	Coast Mfg. & Supply Co.
Weyerhaeuser	Fine granulated board	Weyerhaeuser Sales Co.
Wheelabrator	Mechanical deflashing machines	Wheelabrator Corp.
Whirlclad	Fused coatings and coating process	The Polymer Corp.
Whirlsint	Coating powders	The Polymer Corp.
Whitetex	Aluminum silicate	Southern Clays, Inc.
Wilflex	Vinyl dispersion compounds	Flexible Products Co.
Willson	Thermoplastic, thermosetting film laminations	Willson Camera Co.
Wilmington Fibre	Vulcanized fibre	Wilmington Fibre Specialty Co.
Wilson-art	High-pressure decorative laminated sheets	Ralph Wilson Plastics, Inc.
Windsor Felt	Non-woven bonded fibre material	American Felt Co.
Wing-Stay	Alkylated phenol antioxidant	Goodyear Tire & Rubber Co.
Witcab	Hydrogenated stearic acid	Witco Chemical Co.
Witicizer	Plasticizers	Witco Chemical Co.
Witcolblak	Carbon black	Witco Chemical Co.
Witcolith	Carbon black	Witco Chemical Co.
Wonder Under	As backing and/or lamination, padding, cushioning, reinforcing, or interfacing medium for all types of vinyl and various other plastics	Pellon Corp.
Woodite	Molding material used for molded decorative accessories (Syrocco and Syroccowood)	Syracuse Ornamental Co., Inc.
Wood-Lok	Resin base adhesive	National Starch
Wopalit	Acetate powder for injection molding and extrusion	Worbla, Ltd.
Wopaloid	Celluloid in sheets, tubes, and rods	Worbla, Ltd.
Wopalon	Cellulose acetate in sheets, tubes, and rods	Worbla, Ltd.
Wopavin	PVC in calendered and pressed sheets, tubes, and rods; compounds for injection molding and extrusion	Worbla, Ltd.
Worbla	Nitrocellulose for lacquers and technical uses: bleached linters	Worbla, Ltd.
Wyco	Flexible shaft equipment	Wyzenbeek & Staff, Inc.
Wynsote	Vinyl-coated fabric	The Pantasote Co.

X

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
X-1	Plasticizing oil	Neville Chemical Co.
Xaloy	Wear resistant ferrous alloy used in bimetallic extruder cylinders	Industrial Research Laboratories, Div. Honolulu Oil Corp.
X-Trude	Thermoplastic pipe	Fibercast Co.
XX	Zinc oxides	The New Jersey Zinc Co.
Xylonite	Cellulose nitrate	BX Plastics Ltd.

Y

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Yarway	Impulse steam traps	Yarnall-Waring Co.

Z

TRADE NAME	NATURE OR TYPE OF PRODUCT	COMPANY NAME
Zalba	Rubber antioxidant	E. I. du Pont de Nemours & Co., Inc.
Zelec	Anti-static agent	E. I. du Pont de Nemours & Co., Inc.
Zenite	Rubber accelerator	E. I. du Pont de Nemours & Co., Inc.
Zenoton	Resin finish	E. I. du Pont de Nemours & Co., Inc.
Zerlon	Methacrylate styrene	The Dow Chemical Co.
Zerok 101	Plasticized vinyl coating	Atlas Mineral Products Co.
Zerok 110	Styrene-based coatings	Atlas Mineral Products Co.
Zeva	Foil welding tools and machines	Zeva-Elektrizitats, Ges.
Zoron	Resin finishes	E. I. du Pont de Nemours & Co., Inc.
Zytel	Nylon resin	E. I. du Pont de Nemours & Co., Inc.
Zyrox	Chloride-containing resins & compounds	Union Carbide Corp.

Alphabetical List of Manufacturers and Addresses

A

A.A.A. Plastic Co., 511 Fifth Ave., New York 17, N. Y.
A & B Plastics, Div. of Plastic Supply Corp., 200 Mercer St., Seattle 9, Wash.
ABA Tool & Die Co., Inc., 1395 Tolland Turnpike, Manchester, Conn.
A.B.S. Mfg. Co., Inc., 133 W. 19th St., New York 11, N. Y.
AGP Corp., P. O. Box 318, Peru, Ind.
A & O Plastics Co., 1313 Warren Ave., Downers Grove, Ill.
A & S Steel Rule Die Corp., 195 Chrystie St., New York 2, N. Y.
A.S.K. Plastic Mfg. Co., 1343 N. Howard St., Philadelphia 22, Pa.
Aacon Industries, Inc., 1905 Surf Ave., Brooklyn 24, N. Y.
aaRBee Plastic Co., 200 E. Beach Ave., Inglewood 4, Calif.
Aaron Machinery Co., 45 Crosby St., New York 12, N. Y.
Abbe Engineering Co., 420C Lexington Ave., New York 17, N. Y.
★Abbé, Paul O., Inc., 257 Center Ave., Little Falls, N. J.
Abbott Machinery Co., 117-123 Peters St., Union City, N. J.
Abbott Plastic Machine Corp., 7124 N. Clark St., Chicago 26, Ill.
Able Steel Rule Die Co., 65 Bleecker St., New York 12, N. Y.
Acadia Synthetic Products, Div. of Western Felt Works, 4021-4135 Ogden Ave., Chicago 23, Ill.
Acco Polymers, 59 Kent St., Brooklyn 22, N. Y.
Accurate Gold Stamping Co., Inc., 12 W. 17th St., New York 11, N. Y.
Accurate Match Plate Co., Inc., 1847 W. Carroll Ave., Chicago 12, Ill.
Accurate Molding Corp., 35-20-48th Ave., Long Island City 1, N. Y.
Accurate Steel Rule Die Mfrs., 22 W. 21st St., New York 10, N. Y.
★Ace Plastic Co., 91-30 Van Wyck Expressway, Jamaica 35, N. Y.
Ace Plastic Molding Corp., 5-01-47th Rd., Long Island City 1, N. Y.
Ace Tool & Mfg. Co., 532 Mulberry St., Newark 5, N. J.
Aceto Chemical Co., Inc., 40-40 Lawrence St., Flushing 54, N. Y.
★Acheson Dispersed Pigments Co., Unit of Acheson Industries, 1617 Pennsylvania Blvd., Philadelphia 3, Pa.
★Ackerman Gould Co., 10 Neil Court, P.O. Box 188, Oceanside, N. Y.
Ackerman Plastic Molding Div., Consolidated Iron-Steel Mfg. Co., 1290 E. 53rd St., Cleveland 14, Ohio
Acme Laminating & Plastics Co., Inc., 7207 E. McNichols St., Detroit 12, Mich.
★Acme Machinery & Mfg. Co., Inc., 20 S. Broadway, Yonkers 2, N. Y.
Acme Partition Co., 151 Fabyan Pl., Newark, N. J.
Acme Plastic Products Co., Inc., Harvey & Doyle Sts., Doylestown, Pa.
★Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill.
Acme Scientific Co., 1450 W. Randolph St., Chicago 7, Ill.
★Acromark Co., The, 5-13 Morrell St., Elizabeth 4, N. J.
Action Plastics, Inc., Affiliate of Colorite Plastics of New Jersey, Inc., 50 California Ave., Paterson 3, N. J.
Adams Plastic Products, 309 Findlay St., Cincinnati 14, Ohio
★Adamson United Co., 730 Carroll St., Akron 4, Ohio
Adell Plastics, Inc., 5208 Eleanora Ave., Baltimore 15, Md.
Adhesive Products Corp., 1660 Boone Ave., New York 60, N. Y.
Adhesive Products, Inc., The, 520 E. Shore Highway, Albany 10, Calif.
Admiral Coated Products, Inc., 20 Railroad Ave., Hackensack, N. J.
Advance Molded Plastics Corp., 2601 N. Pulaski Rd., Chicago 39, Ill.
★Advance Solvents & Chemical, Div. of Carlisle Chemical Works, Inc., 500 Jersey Ave., New Brunswick, N. J.
Aerojet-General Corp., Structural Plastics Div., P. O. Box 296, Azusa, Calif.
Aerojet-General Nucleonics, P. O. Box 77, San Ramon, Calif.
★Aetna Electronics Corp., Readington Rd., North Branch, N. J.
Aetna Plastic Die Corp., 7124 Touhy Ave., Chicago 48, Ill.
★Aetna-Standard Div., Blaw-Knox Co., c/o Hale & Kullgren, Inc., P. O. Box 1231, Akron 9, Ohio
Agrashell, Inc., 4560 E. 26th St., Los Angeles 22, Calif.
Airconductors, 367 E. Alondra Blvd., Gardena, Calif.
Air-Formed Products Corp., Pine St. Ext., Nashua, N. H.
Airmate Co., 1150 Nebraska St., Toledo 13, Ohio
Airmatic Valve, Inc., 7313 Associate Ave., Cleveland 9, Ohio
★Air-O-Flow Industries, Inc., Div. of Durable Industries, Inc., 74 Varick St., New York 13, N. Y.
Airoyal Mfg. Co., The, 1990 Springfield Ave., Maplewood, N. J.
Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., 150 E. 42nd St., New York 17, N. Y.
Air-Speed Tool Co., 1502 W. Slauson Ave., Los Angeles 47, Calif.
Akromold, Inc., 102 W. Wilbeth Rd., Akron 1, Ohio
★Akron Presform Mold Co., The, 2038 Main St., Cuyahoga Falls, Ohio
Akron Standard Mold Co., The, 1624 Englewood Ave., Akron 5, Ohio
Aksjeselskapet Ancas, Arendal 6, Norway
Alabama Calcium Products Co., Gantts Quarry, Ala.
Alabaster Plastics Corp., Alabaster, Ala.
Al-Be Industries, 9516 Rayo St., South Gate, Calif.
Albert, P. E., & Son, 21 Nottingham Way, Trenton 3, N. J.
Alcylite Plastics & Chemical Corp., 23874 Pine St., Newhall, Calif.
Alda Plastics, Inc., 154 Grand St., New York 13, N. Y.
Alframine Corp., 72-76 Putnam St., Paterson 4, N. J.
Alkydol Laboratories, Inc., 3242 S. 50th Ave., Cicero 50, Ill.
Alladin Plastics, Inc., 1415 W. 178th St., Gardena, Calif.
Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.
Allegheny Plastics, Inc., Rt. 51 & Thorn Run Rd., Coraopolis, Pa.
Allen, Alva, Industries, 35 & 13 Junction, Clinton, Mo.
Allen Hollander Co., Inc., 385 Gerard Ave., New York 51, N. Y.
Allied Chemical Corp., General Chemical Div., 40 Rector St., New York 6, N. Y.
Allied Chemical Corp., International Div., 40 Rector St., New York 6, N. Y.
★Allied Chemical Corp., National Aniline Div., 40 Rector St., New York 6, N. Y.
Allied Chemical Corp., Nitrogen Div., 40 Rector St., New York 6, N. Y.
★Allied Chemical Corp., Plastics & Coal Chemicals Div., 40 Rector St., New York 6, N. Y.
★Allied Chemical Corp., Semet-Solvay Petrochemical Div., 40 Rector St., New York 6, N. Y.
Allied Engineering & Production Corp., 2421 Blanding Ave., Alameda, Calif.
Allied Engravers, Inc., 552 W. Broadway, New York 12, N. Y.
Allied Mfg. Co., 2200-25th Ave., S., Seattle 44, Wash.
Allied Plastic Mold, Inc., 17 Vreeland St., Lodi, N. J.
Allied Plastics Supply Corp., 75 Cliff St., New York 38, N. Y.
Allied Plasti-Lite Enterprises, Inc., 2712-18 LaSalle St., St. Louis 4, Mo.
Allied Resins, Inc., Commerce & Adams Sts., Conneaut, Ohio
Allis-Chalmers Mfg. Co., 1163 S. 70th St., Milwaukee 1, Wis.
Allison-Campbell Div., American Chain & Cable Co., Inc., 929 Connecticut Ave., Bridgeport 2, Conn.
All Plastics Corp., Field & Main Sts., Avon-By-the-Sea, N. J.
All-Power Mfg. Co., 400 Roosevelt Ave., Montebello, Calif.
All Purpose Roll Leaf Corp., 37 W. Century Rd., Paramus, N. J.
All-Tech Industries, Inc., 350 N. E. 75th St., Miami 68, Fla.
Almac Mfg. Co., 9641 El Poche St., S., El Monte, Calif.
Almac Plastics, Inc., 600 Broadway, New York 12, N. Y.
Alpha Chemical & Plastics Corp., 11 Jabez St., Newark 5, N. J.

★ Indicates advertiser

Alpha Plastics, Inc., 78 Okner Parkway, Livingston, N. J.
Alpine American Corp., 69 Nicholas Rd., Saxonville, Mass.
Alsop Engineering Corp., 1957 Main St., Milldale, Conn.
★Alsteele Engineering Works, Inc., 82 Herbert St., Framingham, Mass.
Alsynite Co. of America, 4654 DeSoto St., San Diego 9, Calif.
Aluminum Co. of America, Chemicals Div., 1501 Alcoa Bldg., Pittsburgh 19, Pa.
Alvimar Mfg. Co., Inc., 1881 Park Ave., New York 35, N. Y.
Ambassador Arts, 124 W. 24th St., New York 11, N. Y.
Amco Plastic Materials, Inc., 96 Fourth St., Brooklyn 31, N. Y.
American Agile Corp., P. O. Box 168, Bedford, Ohio
American Alkyd Industries, Broad & 14th Sts., Carlstadt, N. J.
American-British Chemical Supply, Inc., 180 Madison Ave., New York 16, N. Y.
American Cellular Products, Inc., Box 49, New Castle, Del.
American Combining Corp., 72-36 Burchell Ave., Arverne 92, N. Y.
American Cyanamid Co., Cyanamid International Div., 30 Rockefeller Plaza, New York 20, N. Y.
★American Cyanamid Co., Organic Chemicals Div., Dyes and Intermediates Depts., Bound Brook, N. J.
★American Cyanamid Co., Pigments Div., Bound Brook, N. J.
★American Cyanamid Co., Plastics & Resins Div., 30 Rockefeller Plaza, New York 20, N. Y.
American Edelstaal, Inc., 350 Broadway, New York 13, N. Y.
American Engraving & Machine Co., 719 Livingston St., Elizabeth, N. J.
American Felt Co., Glenville, Conn.
American Hard Rubber Co., Div. of Amerace Corp., Ace Rd., Butler, N. J.
American Hydrotherm Corp., 10-55 Jackson Ave., Long Island City 1, N. Y.
American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.
★American Insulator Corp., New Freedom, Pa.
American Latex Products Corp., 3341 W. El Segunda Blvd., Hawthorne, Calif.
American-Marietta Co., Adhesive, Resin, & Chemical Div., 3400-13th Ave., S.W., Seattle 5, Wash.
American-Marietta Co., Booty Resineers Div., 42 S. Third St., Newark, Ohio
American Metalizing Corp., 150 Bruckner Blvd., New York 54, N. Y.
American Molded Fiberglass Co., 85 Fifth Ave., Paterson 4, N. J.
★American Molding Powder & Chemical Corp., 703 Bedford Ave., Brooklyn 6, N. Y.
American Plasticraft Co., 2027 Williamsbridge Rd., New York 61, N. Y.
American Plastics Corp., 342 Madison Ave., New York 17, N. Y.
American Products Mfg. Co., 8127-33 Oleander St., New Orleans 18, La.
American Pulverizer Co., 1249 Macklind Ave., St. Louis 10, Mo.
American Pyroxylin Corp., 72-86 Second Ave., Box 193, Kearney, N. J.
American Rattan & Reed Mfg. Co., 45 N. Station Plaza, Great Neck, N. Y.
American Reinforced Plastics Co., 851 E. 60th St., Los Angeles 27, Calif.

★ Indicates advertiser

American Resin Corp., 3215 N. Sheffield Ave., Chicago 13, Ill.
American Vinyl Corp., 73-30 Grand Ave., Maspeth 78, N. Y.
American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.
Ameriplastic Co., The, 3161 Torrey Rd., Flint 7, Mich.
Amoco Chemicals Corp., 910 S. Michigan Ave., Chicago 80, Ill.
★Amos Molded Plastics, Div. of Amos-Thompson Corp., 508 S. Kyle St., Edinburg, Ind.
Amperex Electronic Corp., 230 Duffy Ave., Hicksville, N. Y.
Amsco Solvents & Chemicals Co., 4619 Reading Rd., Cincinnati 29, Ohio
★Anchor Plastics Co., Inc., 36-36–36th St., Long Island City 6, N. Y.
Anders Corp., 72 Gray St., Paterson 3, N. J.
Anderson Die & Mfg. Co., 6840 S.W. Macadam, Portland 19, Ore.
Anesite Co., 3575 Touhy Ave., Chicago 45, Ill.
Angier Adhesives Dept., Interchemical Corp., Finishes Div., 120 Potter St., Cambridge, Mass.
Ansbacher-Siegle Corp., 92 Chestnut Ave., Rosebank 5, N. Y.
Anson Tools & Gages, Inc., 1504 W. 12th St., Erie, Pa.
★Antara Chemicals, Sales Div. of General Aniline & Film Corp., 435 Hudson St., New York 14, N. Y.
★Apex Machine Co., 14-13–118th St., College Point 56, N. Y.
Apex Reinforced Plastics Div., White Sewing Machine Corp., Washington & Elm Sts., Cleveland 6, Ohio
★Appleton Machine Co., Doven Div., 618 S. Oneida St., Appleton, Wis.
Applied Plastics Co., Inc., 130 Penn St., El Segundo, California
Applied Plastics Div., Keystone Brass Works, Inc., Box 1100, Erie 2, Pa.
Applied Resins Corp., West Greenbrook Rd., N. Caldwell, N. J.
Aquador Plastics, Inc., 62–18th St., Brooklyn 32, N. Y.
Arabol Mfg. Co., The, 110 E. 42nd St., New York 17, N. Y.
Archer-Daniels-Midland Co., 700 Investors Bldg., Minneapolis 2, Minn.
Architectural Plastics Corp., 1355 River Rd., Eugene, Ore.
★Argenta Products Co., Garnerville, N. Y.
Argo Plastic Products Co., 1400 W. 10th St., Cleveland 13, Ohio
★Argus Chemical Corp., 633 Court St., Brooklyn 31, N. Y.
Aries Laboratories, Inc., 45-33 Davis St., Long Island City 1, N. Y.
Aristocrat Plastics, Inc., 23-25 Sussex Ave., Newark 3, N. J.
Armco Steel Corp., 1939 Armco Ave., Middletown, Ohio
Armen, Inc., 8-22 Astoria Blvd., Long Island City 2, N. Y.
Armitage, John L., & Co., 245 Thomas St., Newark, N. J.
Armored Plastics Co., Div. of Globe-Wernicke Industries, Inc., Lint & Dura Aves., Toledo, Ohio
Armour & Co., Armour Alliance Industries, 16123 Armour St., N. E., Alliance, Ohio
Armstrong Cork Co., West Liberty, Lancaster, Pa.
Armstrong Machine Works, 816 Maple St., Three Rivers, Mich.
Armstrong Products Co., P. O. Box 1, Warsaw, Ind.
Arnkurt Associate Engineers, 210 W. 29th St., New York 1, N. Y.
Aro Equipment Co., 1949 Erie Ave., Bryan, Ohio

Arrem Plastics, Inc., 319 N. Albany Ave., Chicago 12, Ill.
Arrow Plastics Corp., 1 Mattimore St., Passaic, N. J.
Art Decorating Co., 4201 Hudson Blvd., N. Bergen, N. J.
Art Plastics Co., 37-28–56th St., Woodside, N. Y.
Art Plastics Mfg. Co., 799 S. Towne Ave., Los Angeles 21, Calif.
★Artag Plastics Corp., 2853 W. Irving Park Rd., Chicago, Ill.
Artisan Metal Products, Inc., 63 Pond St., Waltham 54, Mass.
Artmor Plastics Corp., 1003 Oldtown Rd., Cumberland, Md.
★Associated Equipment Corp., 209 Pacific National Bank Bldg., Bellevue, Wash.
Associated Rubber & Plastic Corp., 2780 Park Ave., New York 51, N. Y.
Astor Tool & Die Co., 5-01–47th Rd., Long Island City 1, N. Y.
Atkins & Merrill, Inc., Reinforced Plastics Div., Bartlett St., Marlboro, Mass.
Atkins Saw Div., Borg Warner Corp., 402 S. Illinois St., Indianapolis 9, Ind.
Atkins Technical, Inc., 709 Marion Bldg., Cleveland 13, Ohio
Atlantic Mfg. Co., Ninth & Master Sts., Philadelphia 22, Pa.
Atlantic Plastics, Inc., 60 Bonner St., Stamford, Conn.
Atlas Coating Corp., 5-35–47th Ave., Long Island City 1, N. Y.
★Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago 13, Ill.
Atlas Hydraulics Div., Delaware Valley Mfg. Co., Inc., 3576 Ruth St., Philadelphia 34, Pa.
Atlas Mineral Products Co., 151 Ash St., Mertztown, Pa.
Atlas Plastics, Inc., 681 Seneca St., Buffalo 10, N. Y.
Atlas Plastics, Inc., 115 Route 46, Little Ferry, N. J.
Atlas Powder Co., Wilmington 99, Del.
Atlas-Sandt Corp., 240-42 W. 23rd St., New York 11, N. Y.
★Atlas Vac-Machine Corp., 1732 Hudson Ave., Rochester 21, N. Y.
★Atols Tool & Mold Corp., 5005 W. Armitage, Chicago 39, Ill.
Atti Engineering Corp., 108–36th St., Union City, N. J.
★Auburn Plastic Engineering, 4914-24 S. Loomis St., Chicago 9, Ill.
★Auburn Plastics, Inc., 24 McMaster St., Auburn, N. Y.
Augusta Plastics, Inc., 3820 Boston Post Rd., Bronx 69, N. Y.
★Aust & Schüttler u. Co., Graf-Adolf-Strasse 81, Düsseldorf, W. Germany
Austin Industries, Inc., 133 E. Main St., Marlboro, Mass.
★Auto-Blow Corp., Sub. of National Cleveland Corp., 401 Bishop Ave., Bridgeport 10, Conn.
Automatic Plastic Molding Co., 830 Bancroft Way, Berkeley 10, Calif.
★Automatic Process Control Co., 1170 Morris Ave., Union, N. J.
Automold Co., Sub. of Wagner Bros., Inc., 2231 S. Butler Ave., W. Los Angeles 64, Calif.
★Auto-Vac Co., Div. of National Cleveland Corp., 740 Railroad Ave., Bridgeport 6, Conn.
Avco Mfg. Co., Research & Advanced Development Div., 201 Lowell St., Wilmington, Mass.
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AviSun Corp., 1608 Walnut St., Philadelphia 3, Pa.

Axel Plastics Research Laboratories, 1061 Manhattan Ave., Brooklyn 22, N. Y.
Ayres, Samuel, Jr., Associates, 711 Boylston St., Boston 16, Mass.
Azienda Resine Sintetiche, Via Monfalcone 98, Turin, Italy

B

B. B. Chemical Co., 784 Memorial Dr., Cambridge 39, Mass.
★B & E Electroform Co., Greely Ave., Union, N. J.
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Baco Co., 401 Broadway, New York 13, N. Y.
Bacon & Weber, 1121 N. Ashland Ave., Chicago 22, Ill.
★Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, W. Germany
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Baker Bros., Inc., 1000 Post St., Toledo 10, Ohio
Baker Castor Oil Co., The, 40 Avenue A, Bayonne, N. J.
Baker, J. T., Chemical Co., Phillipsburg, N. J.
Baker Perkins, Inc., 1000 Hess St., Saginaw, Mich.
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Balsa Ecuador Lumber Corp., 500 Fifth Ave., New York 36, N. Y.
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Barber-Colman Co., Small Motors Div., P. O. Drawer 99, Rockford, Ill.
★Barber-Colman Co., Wheelco Instruments Div., 1300 Rock St., Rockford, Ill.
Barclay Industries, Inc., 420 Lexington Ave., New York, N. Y.
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★Belding Corticelli Industries, 1407 Broadway, New York 18, N. Y.
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Belon Chemical Co., Inc., 40 Worthington Rd., Cranston 10, R. I.
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Berkeley Engineering & Mfg. Co., 273 Snyder Ave., Berkeley Heights, N. J.
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British Moulded Plastics, Ltd., Walthamstow Ave., London E.4, England
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Brookfield Engineering Laboratories, Inc., 240 Cushing St., Stoughton, Mass.
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Brook Molding Corp., 30 Industrial Way, Norwood, Mass.
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★Capitol Plastics Co., 1122 May St., Lansing, Mich.
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Coz Chemical Corp., Providence Rd., Northbridge, Mass.
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Criterion Decalcomania Co., Inc., 7 E. 42nd St., New York 17, N. Y.
Cromwell Paper Co., 180 N. Wabash Ave., Chicago 1, Ill.
Crook, William A., Co., Inc., 36 Pleasant St., Watertown, Mass.
Crowl, Charles, Co., 11667 McBean Dr., El Monte, Calif.
Crown Aerosol Products Co., 195-40 Jamaica Ave., Hollis, N. Y.
Crown Engineering & Sales Co., 421 Hill St., Harrison, N. J.
Crown Machine & Tool Co., 2800 W. Lancaster St., Ft. Worth, Texas
Crown Machinery, Inc., 2721 S. San Pedro St., Los Angeles 11, Calif.
Crownoil Chemical Co., Inc., 2-14—49th Ave., Long Island City 1, N. Y.
Crucible Steel Co. of America, P. O. Box 2518, Pittsburgh 30, Pa.
Crystal Plastic, Inc., 232-252 Raaffe Pl., Brooklyn 5, N. Y.
Crystal-X Corp., W. Lenni Rd., Lenni Mills, Pa.
★Cumberland Engineering Co., Inc., P.O. Box 216, Providence 1, R. I.
Cumberland Tool Works, 1317 W. Grand Ave., Chicago 22, Ill.
Cuming, M. A., & Co., Inc., 49 Bleecker St., New York 12, N. Y.
Curbell, Inc., 777 Hertel Ave., Buffalo 7, N. Y.
Curry Arts, 522 Green Ridge St., Scranton 9, Pa.
Curtiss-Wright Corp., Curon Div., 50 Rockefeller Plaza, New York 20, N. Y.
Curtiss-Wright Corp., Electronics Div., Industrial Controls Dept., Garden St., Carlstadt, N. J.
Custom Coatings Co., 10819 Venice Blvd., Los Angeles 34, Calif.
★Custom Engineering Co., 2414 McKinley Ave., Erie, Pa.
Custom Extrusion, Inc., County & Home Rd., Sheffield, Mass.
Custom Machine & Design, Inc., P. O. Box 1064, 200 S. Forge St., Akron 9, Ohio
Custom Merchandise Corp., 43 York St., Brooklyn 1, N. Y.
★Custom Plastics, Inc., 1707 N. 25th Ave., Melrose Park, Ill.
Custom Scientific Instruments, Inc., 541-543 Devon St., Kearny, N. J.
Cyanamid International, Div. of American Cyanamid Co., 30 Rockefeller Plaza, New York, N. Y.
Cyclotherm Div., National-U. S. Radiator Corp., Oswego, N. Y.
Cylinder Mfg. Co., 2 Maitland Ave., Hawthorne, N. J.

D

D. & G. Plastics Co., Overholt Rd., Kent, Ohio
★D & R Plastic Welders, Inc., Water St., Hazardville, Conn.
★Dake Corp., 641 Robbins Rd., Grand Haven, Mich.
★Damac Tool Co., 456 E. 166th St., Bronx 56, N. Y.
Damen Tool & Engraving Co., Inc. 4621-4627 N. Olcott Ave., Chicago 31, Ill.
Danberg Chemical Co., Pent Highway, Wallingford, Conn.
Daniels-Kummer Engraving Co., 348 N. Addison Rd., Addison, Ill.
★Daniels, T. H. & J., Ltd., Stroud, Gloucestershire, England
Danielson Mfg. Co., Sub. of Nicholson File Co., Danielson, Conn.
Danson, Barnett J., & Associates, Ltd., 1912 Avenue Rd., Toronto 12, Ontario, Canada
Dapol Plastics, Inc., 53 Northboro St., Worcester 4, Mass.
Darling & Co., 4201 S. Ashland Ave., Chicago 9, Ill.
Dart Mfg. Co., Highway 127, Mason, Mich.
Daubert Chemical Co., 4700 S. Central Ave., Chicago 38, Ill.
★Davidson-Kennedy Co., 1090 Jefferson St., Atlanta 18, Ga.
★Davies, Harry, Molding Co., 1428 N. Wells St., Chicago 10, Ill.
Davies, Helen, Co., 140 W. 57th St., New York 19, N. Y.
★Davies Nitrate Co., Inc., 114 Liberty St., New York 6, N. Y.
Davis, Frank D., Co., Meadow Rd., P. O. Box 292, Nixon, N. J.
★Davis, Joseph, Plastics Co., 450 Schuyler Ave., Kearny, N. J.
★Davis-Standard Div., Franklin Research, 12 Water St., Mystic, Conn.
Dawbarn Bros., Inc., 901 S. Delphine Ave., Waynesboro, Va.
Dawson, F. C., Engineering Co., 641 Washington St., Canton, Mass.
Day, J. H., Co., The, Div. of the Cleveland Automatic Machine Co. 4932 Beech St., Cincinnati 12, Ohio
★Dayton Rubber Co., The, 2342 W. Riverview Ave., Dayton, Ohio
Dean Thermo-Panel Coil Div., Dean Products, Inc., 616 Franklin Ave., Brooklyn 38, N. Y.
DeBell & Richardson, Inc., Water St., Hazardville, Conn.
Debo, L. F., Mfg. Co., 5969 Transit Rd., Depew, N. Y.
★Decar Plastic Corp., 1322 University Ave., Middleton, Wis.
Decatur Plastics, Inc., 407 Holly St., Decatur, Ala.
Decotone Products Div., Fitchburg Paper Co., 193 Kimball St., Fitchburg, Mass.
★Deecy Products Co., 120 Potter St., Cambridge 42, Mass.
Defiance Machine & Tool Co., 1920 S. Vandeventer Ave., St. Louis 10, Mo.
Delkay Plastics Corp., 13441 S. Western Ave., Gardena, Calif.
Delsen Corp., 719 W. Broadway, Glendale 4, Calif.
Delta Products Div. of Air Accessories, Inc., 1400 Henderson St., Fort Worth 1, Texas
★DeMattia Machine & Tool Co., Brighton & Chelsea Rds., Clifton, N. J.
Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo.
Dennison Mfg. Co., 300 Howard St., Framingham, Mass.
Dependable Compressor & Machine Co., Inc., 157 W. 21st St., New York 11, N. Y.
Derby-Shelton Silver Co., Stelray Products, Inc., (Plastics Div.), 65 Shelton Ave., Shelton, Conn.
Desert Sunshine Exposure Tests, 7740 N. 15th Ave., Phoenix, Ariz.
Design Center, Inc., 5-26—46th Ave., Long Island City 1, N. Y.
Design Industries, 1355 River Rd., Eugene, Ore.
Desimone, A. J., Corp., 485 Blvd., E. Paterson, N. J.
★Detroit Macoid Corp., 12340 Cloverdale Ave., Detroit 4, Mich.
★Detroit Mold Engineering Co., 6686 E. McNichols Rd., Detroit, Mich.
Detroit Plastic Products Co., 35135 Groesbeck Highway, Mt. Clemens, Mich.
Detroit Stamping Co., 350 Midland Ave., Detroit 3, Mich.
Devco Engineering, Inc., Peir Lane W., Caldwell, N. J.
★Devcon Corp., Endicott St., Danvers, Mass.
DeVilbiss Co., The, 300 Phillips Ave., Toledo 1, Ohio
Devine, J. P., Mfg. Co., 49th St. & A.V.R.R., Pittsburgh 1, Pa.
Dewes Gumbs Die Co., Inc., 403-5 Broome St., New York 13, N. Y.
Dewey & Almy Chemical Co. Div., W. R. Grace & Co., 62 Whittemore Ave., Cambridge 40, Mass.
★DeWitt Plastics Div., Shoe Form Co., Inc., Aurelius Ave., Auburn, N. Y.
Diamond Alkali Co., Chlorinated Products Div., 300 Union Commerce Bldg., Cleveland 14, Ohio
★Diamond Alkali Co., Plastics Div., 300 Union Commerce Bldg., Cleveland 14, Ohio
★Diamond Alkali Co., Silicate, Calcium, Detergent Div., 300 Union Commerce Bldg., Cleveland 14, Ohio
Diamond Hard Chromium Co., Inc., 463 New Jersey Railroad Ave., Newark 5, N. J.
Dice, J. W., Co., 16 Highwood Ave., Englewood, N. J.
Dielect, Inc., P. O. Box 44, Fords, N. J.
Dielectric Materials Co., 5317 N. Ravenswood Ave., Chicago 40, Ill.
Diemolding Corp., 125 Rasbach St., Canastota, N. Y.
Dietert, Harry W., 9330 Roselawn, Detroit 4, Mich.
★Dillon-Beck Mfg. Co., 1227 Central Ave., Hillside, N. J.
Dillon, W. C., & Co., Inc., 14620 Keswick St., Van Nuys, Calif.
Dimco-Gray Co., 207 E. 6th St., Dayton 2, Ohio
Disogrin Industries, Inc., 510 S. Fulton Ave., Mt. Vernon, N. Y.
Distinctive Embedments, Inc., P. O. Box 2466, Eastside Sta., Providence 6, R. I.
Diversified Technology, Inc., 109 Kinne Rd., E. Syracuse, N. Y.
Divine Bros. Co., 201 Seward Ave., Utica 1, N. Y.
Dixie Plastics Mfg. Co., 3017 N. Galvez St., New Orleans, La.
Dixon Corp., Burnside St., Bristol, R. I.
★Do All Co., The, 254 N. Laurel Ave., Des Plaines, Ill.
Doebeckmun Co., The, Div. of the Dow Chemical Co., 3301 Monroe Ave., Cleveland 1, Ohio
Dodge & Olcott, Inc., 180 Varick St., New York 14, N. Y.
Doggett, Stanley, Inc., 99 Hudson St., New York 13, N. Y.
Dominion Plastics Co., 1913 Blvd., Colonial Heights, Va.
Doré, John L., Co., 5406 Schuler St., Houston 7, Texas
Dornbusch & Co., Kalanderstrasse 19-25, Krefeld 22A, West Germany
Dorrie Process Co., Inc., 60 Greenpoint Ave., Brooklyn 22, N. Y.
Double D Plastics, 501 Cedar St., Greenville, Mich.

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★Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif.
Douglas Mfg. Corp., 200 Lynnfield St., Peabody, Mass.
★Dow Chemical Co., The, Midland, Mich.
Dow Corning Corp., Box 592, Midland, Mich.
★Dowding & Doll, Ltd., 346 Kensington High St., London W. 14, England
Doyle, J. E., Co., 1220 W. Sixth St., Cleveland 13, Ohio
Dracco Div. of Fuller Co., 4063 E. 116th St., Cleveland 5, Ohio
★Drakenfeld, B. F., & Co., Inc., 45 Park Pl., New York 7, N. Y.
Drew, E. F., & Co., Inc. 15 E. 26th St., New York 10, N. Y.
Dreyfus, L. A., Co., P. O. Box 500, S. Plainfield, N. J.
Drying Systems Co., 1800 Foster Ave., Chicago 40, Ill.
Dryomatic Corp., 806 N. Fairfax St., Alexandria, Va.
Duall Plastics, Inc., 764 S. Athol Rd., Athol, Mass.
DuBois, J. Harry, Co., Box 178, Montclair, N. J.
Dumais, Joseph F., Co., Weaver St., Fall River Mass.
★Dumont Corp., 607 Irwin St., San Rafael, Calif.
★Dunning & Boschert Press Co., Inc., 331 W. Water St., Syracuse 2, N. Y.
Duplicon Co., Inc., 100 Turnpike Rd., Westboro, Mass.
★du Pont, E. I., de Nemours & Co., Inc., Wilmington 98, Del.
Dura-Lee Corp., 908 Broadway, Kansas City 5, Mo.
Dura Plastics of New York, Inc., 303 Fifth Ave., New York 16, N. Y.
Durable Formed Products, Inc., 74 Varick St., New York 13, N. Y.
Durable Plastics Co., Inc., 814 Sixth Ave. So., Seattle 4, Wash.
Duralastic Products Co., 5353 Concord Ave., Detroit 11, Mich.
★Durez Plastics Div., Hooker Chemical Corp., 88 Walck Rd., N. Tonawanda, N. Y.
Durolastic Co., 493 Parkhurst, N., Kenmore 23, N. Y.
★Dusenbery, John, Co., Inc., 271 Grove Ave., Verona, N. J.
Du Verre, Inc., Park St., Arcade N. Y.
Dyfoam Corp., 202 E. Cherry St., New Castle, Pa.
Dyna Therm Chemical Corp., 3813 Hoke St., Culver City, Calif.
★Dynamit-Actien-Gesellschaft, (vormals Alfred Nobel & Co.), Troisdorf/Cologne, West Germany. U. S. Rep.: Georg von Opel Corp., 15 William St., New York 5, N. Y.

E

E-W Mold & Tool Co., Inc., 618 E. Market St., Indianapolis 6, Ind.
Eagle Molding Corp., 446–12th St., Brooklyn 15, N. Y.
Eagle-Picher Co., The, American Bldg., Cincinnati 1, Ohio
Eagle Plastics Corp., 23-10 Bridge Plaza S., Long Island City 1, N. Y.
Eagle Roll Leaf Stamping Co., 446–12th St., Brooklyn 15, N. Y.
Eagle Signal Corp., 202–20th St., Moline, Ill.
Eastern Industries, Regent St., E. Norwalk, Conn.
Eastern Moulded Products Co., 7 Madison St., S. Norwalk, Conn.
Eastern Plastic Materials, Slatersville, R. I.
Eastern Plastics Co., Inc., Cottage St., N. Wilbraham, Mass.
Eastern Chemical Products, Inc., Chemical Div., Sub. of Eastman Kodak Co., Kingsport, Tenn.
★Eastman Chemical Products, Inc., Plastics Div., Sub. of Eastman Kodak Co., Kingsport, Tenn.
★Eastman Kodak Co., 343 State St., Rochester 4, N. Y.
Eastman Machine Co., 779 Washington St., Buffalo 3, N. Y.
Eaton Mfg. Co., Dynamatic Div., 3122 14th Ave., Kenosha, Wis.
Eclipse Fuel Engineering Co., 1100 Buchanan, Rockford, Ill.
Eclipse Mfg. Co., 48 S. Old Rand Rd., Lake Zurich, Ill.
Economy Engineering Co., 4511 W. Lake St., Chicago 24, Ill.
Edison, S. M., Chemical Co., 2710 S. Parkway, Chicago 16, Ill.
Edwards High Vacuum, Inc., 1920 Buffalo Ave., Niagara Falls, N. Y.
Efka Plastic Corp., 1121 Clinton, Hoboken, N. J.
★Egan, Frank W., & Co., 671 S. Adamsville Rd., Somerville, N. J.
Ehrman, Ernst, Industrial Design, 64 W. 56th St., New York 19, N. Y.
Eisler Engineering Co., Inc., 754 S. 13th St., Newark 3, N. J.
Electric Auto-Lite Co., The, General Products Group, Champlain, Toledo 1, Ohio
Electric Trading Co., 313-315 Canal St., New York 13, N. Y.
Electrochemical Industries, Inc., 35 Amory St., Worcester 3, Mass.
Electro-Chemical Products Corp., 16190 Saranac Rd., Cleveland 10, Ohio
★Electro-Devices, Inc., Servospeed Div., 4-6 Godwin Ave., Paterson, N. J.
Electroforms, Inc., 239 E. 165th St., Gardena, Calif.
Electro-Mechano Co., The, 241 E. Erie St., Milwaukee 2, Wis.
Electromold Corp., 140 Enterprise Ave., Trenton 9, N. J.
Electro Plastic Fabrics, Inc., 64 First St., N.E., Pulaski, Va.
Electro Plastics Corp., 1201 Levee St., Dallas 7, Texas
Electro-Tech Equipment Co., 308 Canal St., New York 13, N. Y.
Electro-Technical Products Div., Sun Chemical Corp., 113 E. Centre St., Nutley 10, N. J.
Electronic Mechanics, Inc., 101 Clifton Blvd., Clifton, N. J.
Electronic Processes Corp. of Calif., 436 Bryant, San Francisco 7, Calif.
Electronic Wave Products, Inc., 15 E. 22nd St., New York 10, N. Y.
Elgin National Watch Co., Abrasives Div., 107 National St., Elgin 10, Ill.
Ellay Rubber Co., 1200 S. Central Ave., Los Angeles 21, Calif.
Ellen Products Co., Maple & Fairmount Aves., Haverstraw, N. Y.
Ellies, Dave, Industrial Design, Inc., 799 W. Goodale Blvd., Columbus 8, Ohio
Elm Coated Fabrics Co., Inc., 261 Fifth Ave., New York 16, N. Y.
★Elmes Engineering Div., American Steel Foundries, 1150 Tennessee Ave., Cincinnati 29, Ohio
Elton, Ted, 84 Lawrence Dr., N. White Plains, N. Y.
Elyria Molding & Engineering Co., 317 Prospect St., Elyria, Ohio
★Emeloid Co., Inc., The, 1239 Central Ave., Hillside 5, N. J.
Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.
Emerson Plastics Corp., 1383 Seabury Ave., Bronx 61, N. Y.
★Emery Industries, Inc., 4200 Carew Tower, Cincinnati 2, Ohio
Emery, Vern, Co., 10647 Wixom St., Sun Valley, Calif.
Emhart Mfg. Co., Hudson Div., Union Turnpike, Hudson, N. Y.
Emhart Mfg. Co., Portland Div., Portland, Conn.
Endura Corp., 45 N. 4th St., Quakertown 11, Pa.
Enduro Tool & Engineering Co., 4134 W. Chicago Ave., Chicago 51, Ill.
★Engelking Patterns, Inc., 1537 Hutchins Ave., Columbus, Ind.
Engineered Nylon Products, Inc., 2530 By-Pass Rd., Elkhart 2, Ind.
Engineered Plastics, Inc., Drawer P, Watertown, Conn.
★Engineered Plastics, Inc., Chase St., Gibsonville, N. C.
Engineered Products, Inc., 105 Ford Lane, Hazelwood 22, Mo.
Engineering Associated, 67 Main St., Winona, Minn.
★Engineering Laboratories, Inc., Colfax Ave., Pompton Lakes, N. J.
Engineering Plastics Co., 45 E. Walnut St., Pasadena, Calif.
★Engis Equipment Co., Hyprez Div., 431 S. Dearborn St., Chicago, Ill.
Englander Co., Inc., The, Industrial Plastics Div., 227 N. Warwick Ave., Baltimore 23, Md.
★English Mica Co., 79 Prospect St., Stamford, Conn.
★Enjay Co., Inc., 15 W. 51st St., New York 2, N. Y.
★Entoleter Div., Safety Industries, Inc., 1187 Dixwell Ave., New Haven, Conn.
Entwistle Mfg. Corp., 1475 Elmwood Ave., Providence 7, R. I.
Epoxylite Corp., 10829 E. Central Ave., El Monte Calif.
Equitable Paper Bag Co., Inc., 45-50 Van Dam St., Long Island City 1, N. Y.
Erdco Engineering Corp., Official Rd. & Westgate Dr., Addison, Ill.
Erickson, Wallace A., & Co., 842 N. Wells St., Chicago 10, Ill.
★Erie Engine & Mfg. Co., 953 E. 12th St., Erie, Pa.
★Erie Foundry Co., 1253 W. 12th St., Erie, Pa.
Erie Plastics Co., 1221 Walnut St., Erie, Pa.
★Erie Resistor Co., 1345 W. 12th St., Erie 6, Pa.
Erinac Equipment Corp., 225 Lafayette St., New York 12, N. Y.
Erinoid, Ltd., W. Halkin St., Belgrave Sq., London, S.W.1, England
Eronel Industries, 12607 Cerise Ave., Hawthorne, Calif.
★Escambia Chemical Corp., 261 Madison Ave., New York 16, N. Y.
Essex Plastic Machinery Co., 53 Rantoul St., Beverly, Mass.
Euclid Engineering Co., 1st & A Sts., Upland, Calif.
Evans-Zeier Plastic Co., Highway 51 (Zeier Service Rd.), Madison 4, Wis.
Eveready Plastics, 151 Merritts Ave., N.E., Atlanta 8, Ga.
Everlite Corp., 1218 E. Cherry St., Seattle 22, Wash.
Ever Ready Label Corp., 357 Cortlandt St., Belleville 9, N. J.
Evers Industries, Inc., 3-01–27th Ave., Long Island City 2, N. Y.

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Exact Weight Scale Co., 919 W. 5th Ave., Columbus 15, Ohio
Excel-Mold, Inc., 939 E. Troy Ave., Indianapolis 3, Ind.
Excel Plastic Mfg. Corp., 458 W. 168th St., New York 32, N. Y.
Exeter Mfg. Co., 1431 Broadway, New York 34, N. Y.
Extruders, Inc., 3232 W. El Segundo Blvd., Hawthorne, Calif.

F

F & F Mold & Die Works, Inc., 103 Sachs St., Dayton 3, Ohio
Fabric Leather Corp., 16 W. 32nd St., New York 1, N. Y.
Fabrico Mfg. Corp., 1714 W. Division St., Chicago 22, Ill.
★Fabricon Products, Inc., 1721 W. Pleasant Ave., River Rouge, Mich.
Fabri-Form Co., The, 258 W. Main St., Byesville, Ohio
Fabri-Kal Corp., 242 E. Kalamazoo Ave., Kalamazoo, Mich.
Fabrite Metals Corp., 1547 Covert St., Brooklyn 27, N. Y.
★Faeco Machine Co., Inc., 643—21st Ave., Box 6, Paterson, N. J.
Falcon Equipment Co., 13th St., New Brighton, Pa.
Falcon, Inc., 2050 Broadway, Santa Monica, Calif.
Falge Engineering Corp., 4733 Elm St., Bethesda 14, Md.
Falk Glass & Plastic Co., Inc., 48-10 Astoria Blvd., Long Island City 3, N. Y.
★Falls Engineering & Machine Co., The, 1734 Front St., Cuyahoga Falls, Ohio
Falls Hollow Staybolt Co., 7 Portage Trail, Cuyahoga Falls, Ohio
★Famco, Inc., 6201 Strawberry Lane, Louisville 9, Ky.
★Famco Machine Co., 3100 Sheridan Rd., Kenosha, Wis.
Faratron, 4447 Union Pacific Ave., Los Angeles 23, Calif.
Farbenfabriken Bayer, A.G., Leverkusen, West Germany
★Farbwerke Hoechst, A.G., (vormals Meister Lucius & Bruning), Frankfurt/Main-Hoechst, West Germany. U. S. Distributor: Carbic Color & Chemical Co., Inc.
Farley & Loetscher Mfg. Co., Plastics Div., 7th & White Sts., Dubuque, Iowa
Farragut Plastics Corp., 953 E. 51st St., Brooklyn 3, N. Y.
★Farrel-Birmingham Co., Inc., Ansonia, Conn.
★Farrel-Birmingham Co., Inc., Watson-Stillman Press Div., 565 Blossom Rd., Rochester 10, N. Y.
Farrington Texol Corp., 2000 Main St., Walpole, Mass.
Fassler, M. J., & Co., Inc., 1241-1245 Gates Ave., Brooklyn 21, N. Y.
Fasson Products, 250 Chester St. Painesville, Ohio
Favorite Plastic Corp., 39-45 Warren St., Brooklyn 1, N. Y.
Fawn Plastics Co., Inc., 2301 York Rd., Timonium, Md.
★Fecken-Kirfel Maschinenfabrik, Goebbelgasse 15, Aachen, West Germany. U. S. Distributor: General Foam Corp., 640 W. 134th St., New York 31, N. Y.
Federal Container Corp., 4300 Olson Highway, Minneapolis 22, Minn.
Federal Industries, A Textron Co., 681 Main St., Belleville 9, N. J.

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Federico, Joseph B., 1600 East Ave., Rochester 10, N. Y.
Fellner & Ziegler G.m.b.H., Kreuznacher Strasse 29, Frankfurt/Main, West Germany
★Fellows Gear Shaper Co., The, Plastics Machine Div., 78 River St., Springfield, Vt.
Felsenthal, G., & Sons, 3500 N. Kedzie Ave., Chicago 18, Ill.
Felters Co., The, 210 South St., Boston 11, Mass.
Fenco Mfg. Co., 2685 Mogadore Rd., Akron 12, Ohio
Fenwal, Inc., Pleasant St., Ashland, Mass.
Ferro Chemical Corp., Div. of Ferro Corp., 450 Krick Rd., Bedford, Ohio
★Ferro Corp., Color Div., 4150 E. 56th St., Cleveland 5, Ohio
★Ferro Corp., Fiber Glass Div., Fiber Glass Rd., Nashville 11, Tenn.
Ferro Corp., Patterson Equipment Div., E. Liverpool, Ohio
Ferry Machine Co., W. Main St. Ext., Kent, Ohio
Fersons Industries, Inc., 16 W. 32nd St., New York 1, N. Y.
Fiber Chemical Corp., Bond St., Cliffwood, N. J.
Fibercast Co., Div. of the Youngstown Sheet & Tube Co., Box 727, Sand Springs, Okla.
Fiberesin Plastics Co., 756 E. Wisconsin Ave., Oconomowoc, Wis.
★Fiberfil, Inc., Fox Farm Rd., Warsaw, Ind.
Fiberform, Inc., P. O. Box 131, Oconomowoc, Wis.
Fiberglass Boat Co., P. O. Box 212, Somerset, Pa.
Fiber Glass Industries, Inc., Homestead Pl., Amsterdam, N. Y.
Fiber Glass Plastic, Inc., 7395 N.W. 34th Court, Miami 47, Fla.
★Fiberite Corp., The, 516 W. 4th St., Winona, Minn.
Fiberlay, Inc., 1158 Fairview N., Seattle 9, Wash.
Fibro Corp., 175 Terminal Ave., Clark, N. J.
Fields, Charles S., Inc., 199 Garibaldi Ave., Lodi 1, N. J.
Fife Mfg. Co., P. O. Box 9815, Oklahoma City 18, Okla.
Filo Color & Chemical Corp., 347 Madison Ave., New York 17, N. Y.
Filon Plastics Corp., 2051 E. Maple Ave., El Segundo, Calif.
★Fine Organics, Inc., 205 Main St., Lodi, N. J.
★Finish Engineering Co., Inc., 1115 Cherry St., Erie, Pa.
Finn & Fram, 9765 Shadow Island Dr., Sunland, Calif.
Fiore, William M., Inc., 269—41st St., Brooklyn 32, N. Y.
Firestone Plastics Co., Div. of the Firestone Tire & Rubber Co., P. O. Box 690, Pottstown, Pa.
Firmaline Products, Inc., 9 Pierce Ave., Midland Park, N. J.
First Machinery Corp., 209-289—10th St., Brooklyn 15, N. Y.
Firth Sterling, Inc., 3113 Forbes Ave., Pittsburgh 30, Pa.
Fischer, Johann, Maschinenbau, Lohmar, bez., Cologne, West Germany. U. S. Rep.: Barclay Industries, 420 Lexington Ave., New York, N. Y.
Fischer & Porter Co., 30 Warminster Rd., Hatboro, Pa.
Fisher Scientific Co., 711 Forbes Ave., Pittsburgh 19, Pa.

Fitchburg Paper Co., Decotone Products Div., Kimball St., Fitchburg, Mass.
★Fjellman American, Inc., 105 Republic Ave., Joliet, Ill.
Flambeau Plastics Corp., 800 Lynn Ave., Baraboo, Wis.
Flexaust Co., The, 100 Park Ave., New York 17, N. Y.
Flexcon Co., Wall St., Spencer, Mass.
Flexcraft Industries, 527 Avenue P, Newark 5, N. J.
Flexfirm Products, 2300 N. Chico Ave., S. El Monte, Calif.
Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio
Flexible Products Co., 312 Dobbs St., Marietta, Ga.
Flexigrip, Inc., 504 E. 74th St., New York 21, N. Y.
Flex-O-Glass, Inc., 1100 N. Cicero Ave., Chicago 51, Ill.
★Flick-Reedy Corp., Miller Fluid Power Div., 7N015 York Rd., Bensenville, Ill.
★Flightex Fabrics, Inc., 93 Worth St., New York 13, N. Y.
Florian, Gordon, 97 Argonne St., Bridgeport 4, Conn.
Foam King, Inc., 1816 Boston Rd., New York 60, N. Y.
Food Film, Inc., 79 Clinton Rd., Caldwell Township, N. J.
★Food Machinery & Chemical Corp., Chemicals & Plastics Div., 161 E. 42nd St., New York 17, N. Y.
Foredom Electric Co., Inc., Bethel, Conn.
Foremost Food & Chemical Co., El Dorado Div., P. O. Box 599, Oakland 4, Calif.
Formica Corp., The, Sub. of American Cyanamid Co., 4614 Spring Grove Ave., Cincinnati 32, Ohio
Forrest Mfg. Co., 231 State Highway #17, Rutherford, N. J.
Fortin Plastics, Inc., 14811 Keswick St., Van Nuys, Calif.
Fortney Mfg. Co., Inc., 247 New Jersey Railroad Ave., Newark 5, N. J.
★Foster & Allen, Inc., 26 Commerce St., Chatham, N. J.
★Foster Grant Co., Inc., 289 N. Main St., Leominster, Mass.
Fostoria Pressed Steel Corp., The, 1200 N. Main St., Fostoria, Ohio
Foxboro Co., The, 38 Neponset Ave., Foxboro, Mass.
France Engineering Co., The, 15501 Montrose Ave., Cleveland 11, Ohio
Francis Industries, 25 E. Depot St., Pataskala 2, Ohio
★Frank, J. P., Chemical Corp., 5410 Avenue U, Brooklyn 34, N. Y.
Frank, J. P., & Co., Inc., 5410 Avenue U, Brooklyn 34, N. Y.
Frank Plastics Corp., 91 Pallister, Detroit 2, Mich.
Franklin Fibre-Lamitex Corp., 18th St., E. of Market on P.R.R., Wilmington 99, Del.
Franklin Mineral Products Co., Depot, Franklin, N. C.
Franklin Plastics, Inc., 315 Grant St., Franklin, Pa.
★Freeman Chemical Corp., 211 E. Main St., Port Washington, Wis.
Freeport Plastic Sheet Corp., Maple Pl., Freeport, N. Y.
★French Oil Mill Machinery Co., The, 1040 W. Greene St., Piqua, Ohio
Fried Novelties, 5215 New Utrecht Ave., Brooklyn 19, N. Y.
Frisch Doll Supply Co., Inc., 375 W. Broadway, New York 12, N. Y.
Fritzsche Bros., Inc., 76 Ninth Ave., New York 11, N. Y.

Froehling & Robertson, Inc., 814 W. Cary St., Richmond 6, Va.
Fukal, Alfred F., 3752 Tangley Rd., Houston 5, Texas
Fuller, H. B., Co., 255 Eagle St., St. Paul 2, Minn.
★Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39, Calif.
Futura, Inc., 2400 S. Ashland Ave., Chicago 8, Ill.

G

G.M.C. Process Corp., 718 Broadway, New York 3, N. Y.
GPE Controls, Inc., 240 E. Ontario St., Chicago 11, Ill.
G & S Label Corp., 49 W. 27th St., New York 1, N. Y.
★G-W Plastic Engineers, Inc., Pleasant St., Bethel, Vt.
Gabriel Mfg. Co., 15 Maple Ave., Haverstraw, N. Y.
Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.
Galland-Henning Mfg. Co., 2761 S. 31st St., Milwaukee 46, Wis.
★Gane Bros. & Lane, Inc., 1335 W. Lake St., Chicago 7, Ill.
Garan Chemical Corp., 210 E. Olive St., P. O. Box 192, Gardena, Calif.
Gardner-Denver Co., 100 Williamson St., Quincy, Ill.
Gardner Laboratory, Inc., 5523 Landy Lane, Bethesda 14, Md.
★Garfield Mfg. Co., 10 Midland Ave., Wallington, N. J.
Garray Plastics, Inc., 333 Bergen Ave., Kearny N. J.
Garrett Corp., The, Air Cruisers Div., Route 34, Wall Township, N. J.
Garvan, P., Inc., 236 Hamilton St. Hartford, Conn.
Gary Enterprises, Inc., 249–49th St., Brooklyn 20, N. Y.
Gaylord Container Corp., 111 N. 4th St., St. Louis 2, Mo.
Gaylord Plastics, Inc., 1643–19th St., Santa Monica, Calif.
Gaynes Engineering Co., 1642 W. Fulton St., Chicago 12, Ill.
Geauga Industries Co., Old State Rd., Middlefield, Ohio
★Geigy Industrial Chemicals, P. O. Box 430, Yonkers, N. Y.
Geigy, J. R., S. A., Basel 16, Switzerland
★Geissel Mfg. Co., Inc., 109 Long Ave., Hillside, N. J.
Gem City Trading Corp., P. O. Box 941, Dayton 1, Ohio
Gemloid Corp., 38-40–10th St., Long Island City, N. Y.
★General American Transportation, Plastics Div., 135 S. LaSalle St., Chicago 90, Ill.
General Box Co., 1825 Miner St., Des Plaines, Ill.
General Color Co., Inc., 24 Avenue B, Newark 5, N. J.
General Die Mold Co., 548 N. Sacramento Blvd., Chicago 12, Ill.
★General Dyestuff Co., A Sales Div. of General Aniline & Film Corp., 435 Hudson St., New York 14, N. Y.
★General Electric Co., Apparatus Sales Div., 1 River Rd., Schenectady 5, N. Y.
★General Electric Co., Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass.
General Electric Co., Laminated Products Dept., Coshocton, Ohio

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★General Electric Co., Lamp Metals & Components Dept., 21800 Tungsten Rd., Cleveland 17, Ohio
General Electric Co., Silicone Products Dept., Waterford, N. Y.
General Engineering Co. (Radcliffe) Ltd., Station Works, Bury Rd., Radcliffe, Lancs., England
General Fibre Co., 217 Cedar St., St. Louis 2, Mo.
General Fibre Co., Inc., South St., Walpole, Mass.
General Foam Corp., 640 W. 134th St., New York 31, N. Y.
General Foam Products, 4400 District Blvd., Vernon, Calif.
★General Industries Co., Taylor & Olive Sts., Elyria, Ohio
General Machine & Tool Works, 40261 13 Mile Rd., Walled Lake, Mich.
General Mills, Inc., Box 191, Kankakee, Ill.
★General Mills, Inc., Oilseeds Div., 9200 Wayzata Blvd., Minneapolis 26, Minn.
General Molded Products, Inc., 1365 Lee St., Des Plaines, Ill.
General Plastics Corp., 2260 Centinela Ave., Los Angeles 64, Calif.
★General Plastics Corp., 1400 N. Washington St., Marion, Ind.
General Plastics Corp., 165 Third Ave., Paterson, N. J.
General Plastics, Inc., 7616 W. Michigan Ave., Kalamazoo, Mich.
General Plastics Mfg. Co., 3481 S. 35th St., Tacoma 2, Wash.
General Printing Ink Co., Div. of Sun Chemical Corp., 750 Third Ave., New York 17, N. Y.
General Research & Supply Co., 572 S. Division Ave., Grand Rapids 3, Mich.
★General Roll Leaf Mfg. Co., 85-03–57th Ave., Elmhurst 73, N. Y.
General Tire & Rubber Co., The, 1700 Factory Ave., Marion, Ind.
General Tire & Rubber Co., Bolta Products Div., 70 Garden St., Lawrence, Mass.
★General Tire & Rubber Co., Chemical Div., 1708 Englewood Ave., Akron 9, Ohio
General Tire & Rubber Co., Textileather Div., 607 Madison Ave., Toledo 3, Ohio
Genesee Laboratory, Inc., 16 Garden St., Auburn, N. Y.
Geneve Mfg. Corp., 288 Third St., Trenton, N. J.
★Georgia Kaolin Co., 433 N. Broad St., Elizabeth 3, N. J.
Georgia Marble Co., The, Calcium Products Div., Tate, Ga.
Gerin Mfg. Co., Inc., 683-685 N. 5th St., Newark 7, N. J.
★Gering Products, Inc., North 7th St. & Monroe Ave., Kenilworth, N. J.
Gershen, Irvin J., 1877 Springfield Ave., Maplewood, N. J.
Gessner Mfg. Co., 241 N. Main St., Ambler, Pa.
Gibbs Mfg., 725 Channing Way, Berkeley 7, Calif.
Gibson Associates, Inc., 390 North Ave. E., Cranford, N. J.
Gidion's, 41, Via Compagnoni, Milan, Italy
Gill, M. C., Corp., 1418 N. Potrero, S. El Monte, Calif.
Gilman Bros. Co., The, Gilman, Conn.
Girdler Process Equipment Div., Chemetron Corp., 334 E. Broadway, Louisville 1, Ky.
Gisholt Machine Co., 1245 E. Washington, Madison 4, Wis.

Gits, J. P., Molding Corp., 4600 W. Huron St., Chicago 44, Ill.
Gladwin Plastics, Inc., 165 Courtland St., N.E., Atlanta 3, Ga.
Glasflex, Inc., Valley Rd., Stirling, N. J.
Glaskyd, Inc., Eckel Rd., Perrysburg, Ohio
Glasply Corp., 70 Lyons Pl., Mt. Vernon 5, N. Y.
Glass Laboratories, 863–65th St., Brooklyn 20, N. Y.
Glastic Corp., The, 4321 Glenridge Rd., Cleveland 21, Ohio
Glengarry Processes, Inc., Bay Shore, N. Y.
★Glenn Electric Heater Corp., 372 Jelliff Ave., Newark 8, N. J.
Glidden Co., The, 900 Union Commerce Bldg., Cleveland 14, Ohio
★Glidden Co., The, Chemicals-Pigments-Metals Div., 3901 Hawkins Point Rd., Baltimore 26, Md.
Globe Imperial Div., Ainsworth-Precision Castings Co., 2025 Kishwaukee St., Rockford, Ill.
Globe Molded Plastics, Inc., N. 6th & Washington, Byesville, Ohio
★Glo-Brite Foam Plastic Products, 6415 N. California Ave., Chicago 45, Ill.
Goldberg & O'Brien Electric Co., 17 S. Jefferson St., Chicago 6, Ill.
Gomar Mfg. Co., Inc., 1501 W. Blancke St., Linden, N. J.
Goodall-Sanford, Inc., Goodall-Sanford Rd., Reading, Mass.
Goodren Products Corp., 101 W. Forest Ave., Englewood, N. J.
★Goodrich, B. F. Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio
Goodrich, B. F., Industrial Products Co., 500 S. Main St., Akron 18, Ohio
Goodrich, B. F., Industrial Products Co., Plastic Products Div., Marietta, Ohio
Goodrich-Gulf Chemicals, Inc., 3121 Euclid Ave., Cleveland 15, Ohio
★Goodyear Tire & Rubber Co., Chemical Div., 1485 Archwood Ave., Akron 16, Ohio
Gordon Chemicals, Inc., 500 "A" St., Wilmington, Del.
Gordon-Lacey Chemical Products Co., Inc., 57-02–48th St., Maspeth 78, N. Y.
Gore, Fred M., 2902 Routh St., Dallas 4, Texas
Gore, W. L., & Associates, 487 Papermill Rd., Newark, Del.
Goren, H. L., Co., 7312 N. Rogers Ave., Chicago 26, Ill.
★Gorton, George, Machine Co., 1100 W. 13th St. Racine, Wis.
Gotham Ink & Color Co., 5-19–47th Ave., Long Island City 1, N. Y.
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★Goulding Mfg. Co., 2929 River St., Saginaw, Mich.
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★Grace, W. R., & Co., Polymer Chemicals Div., 225 Allwood Rd., Clifton, N. J.
Grand Haven Plastics Co., 5140 Marion, Grand Haven, Mich.
Grant & Roth Plastics, Inc., 2311 N.W. Johnson St., Portland 10, Ore.
Grayhill Moldtronics, Inc., 561 Hillgrove Ave., LaGrange, Ill.
★Great American Plastics Co., 650 Water St., Fitchburg, Mass.
Great Lakes Solvents, Inc., 530 W. Bloomingdale Ave., Chicago 47, Ill.

Green Instrument Co., Inc., 385 Putnam Ave., Cambridge 39, Mass.
Greene Plastics Corp., Canonchet Rd., Hope Valley, R. I.
Greene, Ray, & Co., 508 S. Byrne Rd., Toledo 9, Ohio
Greenerd Arbor Press Co., 41 Crown St., Nashua, N. H.
Greer Hydraulics, Inc., N. Y. International Airport, Jamaica 30, N. Y.
Gregstrom Corp., 14 Davis St., Cambridge 39, Mass.
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Greising Engineering Co., 400 Singley Ave., Runnemede, N. J.
Gries Reproducer Corp., 28 Second St., New Rochelle, N. Y.
Grieve-Hendry Co., Inc., 1401 W. Carroll Ave., Chicago 7, Ill.
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Grigoleit Co., The, 740 E. North St., Decatur, Ill.
Groov-Pin Corp., 1125 Hendricks Causeway, Ridgefield, N. J.
Groppe, Henry, Commerce Bldg., 1534 Tennessee Rd., Houston 2, Texas
Grover, Frederic S., Associates, 42 East Ave., Rochester 4, N. Y.
Gruen, Robert, Associates, 509 Madison Ave., New York 22, N. Y.
★Guild Electronics, Inc., Dynatherm Div., 388 Broadway, New York 13, N. Y.
Guild Molders, Inc., 42 Hayes St., Elmsford, N. Y.
Gulf Oil Corp., Petrochemicals Dept., P. O. Box 1166, Pittsburgh 30, Pa.
Gulliksen, Wm. M., Mfg. Co., Newton Lower Falls 62, Mass.
Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.
Gump, B. F., Co., 1325 S. Cicero Ave., Chicago 50, Ill.
Gusmer, A., Inc., Upper Barron Ave., Woodbridge, N. J.

H

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Hake Mfg. Co., Inc., 1215 Midvale Ave., S. W., Roanoke, Va.
Hale & Kullgren, Inc., 613 E. Tallmadge Ave., Box 1231, Akron, Ohio
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Haller Plastics Corp., 38-40–10th St., Long Island City 1, N. Y.
Hallikainen Instruments, 1341–7th St., Berkeley 10, Calif.
Halogen Insulator & Seal Corp., 9960 Pacific Ave., Franklin Park, Ill.
Halsey, Inc., 40 Poplar St., Scranton 9, Pa.
★Halvorfold-Kwikprint Co., 700 E. Union, Jacksonville, Fla.
★Hamac Packmaschinen G.m.b.H., Berliner Allee 61, Dusseldorf, West Germany
Hamilton Tool Co., The, 917 Hanover St., Hamilton, Ohio
Hampden Mfg. Co., Inc., Bridge St., Three Rivers, Mass.
Hankins Container Co., Div. of The Flintkote Co., 14801 Emery Ave., Cleveland 35, Ohio
Hanley Plastics Co., Manchester Rd. at Summit Ave., St. Louis 17, Mo.
Hanna Engineering Works, 1767 Elston Ave., Chicago 22, Ill.
Hannifin Co., A Div. of Parker-Hannifin Corp., 554D S. Wolf Rd., Des Plaines, Ill.
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Har-Conn Chrome Co., The, 603 New Park Ave., West Hartford 10, Conn.
Harcort Mfg. Co., 446 W. Lake St., Ravenna, Ohio
Hardman, H. V., Co., Inc., 571 Cortlandt St., Belleville 9, N. J.
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Harrison & Co. Inc., 487 Groveland St., Haverhill, Mass.
★Harshaw Chemical Co., The, 1945 E. 97th St., Cleveland 6, Ohio
Harstil Industries Co., 24955 Harper St., St. Clair Shores, Mich.
Hart, William A., & Associates, Route 2, Box 278, St. Charles, Ill.
Hartbauer Tool & Die Co., 817 N.W. 23rd Ave., Portland 10, Ore.
Harte & Co., Inc., 16 E. 34th St., New York 16, N. Y.
★Hartig Extruders Div., Midland-Ross Corp., 1137 Globe Ave., Mountainside, N. J.
Hartland Plastics, Inc., 340 Maple Ave., Hartland, Wis.
Harva Co., Inc., The, 100 Fair St., Schoharie, N. Y.
★Harvey, Guy P., & Son Corp., 40 Spruce St., Leominster, Mass.
★Harwick Standard Chemical Co., 60 S. Seiberling St., Akron 5, Ohio
Hassall, John, Inc., Box 2243, Westbury, N. Y.
Hastings & Co. Inc., 2314 Market St., Philadelphia 3, Pa.
Hastings Plastics, Inc., 1551–12th St., Santa Monica, Calif.
Haveg Industries, Inc., Technical Dept., 900 Greenbank Rd., Wilmington 8, Del.
Hawley Products Co., 333 N. 6th St., St. Charles, Ill.
★Hayden Mica Co., Inc., Main St., Wilmington, Mass.
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Haynes & Haynes Ltd., 32 Old Church St., London, S.W.3, England
Hays Mfg. Co., 801 W. 12th St., Erie, Pa.
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Hedrix, Frank, Co., 14908 Verdura Rd., Paramount, Calif.
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Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio
Heine Industries, Inc., Route 3, Box 53, Freeport, Ill.
★Heinrich Equipment Corp., 111 Eighth Ave., New York 11, N. Y. U. S. Rep. for Reifenhauser Plastics Machinery Corp.
Helicoid Gage Div., American Chain & Cable Co., Inc., 929 Connecticut Ave., Bridgeport 2, Conn.
Helmac Plastics, Inc., 10860–49th St., N., Pinellas Park, Fla.
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Hendrick Mfg. Corp., 11 Selman St., Marblehead, Mass.
Henley & Co., Inc., 202 E. 44th St., New York 17, N. Y.
Henriques, J. B., Inc., 521 Fifth Ave., New York 21, N. Y. U. S. Rep. for Imperial Chemical Industries, Ltd., Plastics Div.
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★Hercules Powder Co., Inc., 900 Market St., Wilmington 99, Del.
Heresite & Chemical Co., 822 S. 14th St., Manitowoc, Wis.
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Hermes Engravers, Inc., 154 W. 14th St., New York 11, N. Y.
Hermes Plastics, Inc., 154 W. 14th St., New York 11, N. Y.
Hermes Sonic, 154 W. 14th St., New York 11, N. Y.
Hero Mfg. Co., Inc., 15 Sproat St., Middleboro, Mass.
Hess, Goldsmith & Co., Inc., Div. of Burlington Industries, 1400 Broadway, New York 18, N. Y.
Hewitt, C. B., & Bros., Inc., 23-25 Greene St., New York 13, N. Y.
Hexcel Products, Inc., 2332 Fourth St., Berkeley 10, Calif.
Heyden Chemical Div., Heyden Newport Chemical Corp., 342 Madison Ave., New York 17, N. Y.
High Strength Plastics Corp., 1407 W. Jackson Blvd., Chicago 7, Ill.
High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.
High Voltage Engineering, S. Bedford St., Burlington, Mass.
Hilton-Davis Chemical Co., Div., The, 2235 Langdon Farm Rd., Cincinnati 13, Ohio
Hinde & Dauch Div., West Virginia Pulp & Paper Co., P. O. Box 861, Sandusky, Ohio
★Hobbs Mfg. Co., 26 Salisbury St., Worcester 5, Mass.
★Hob-Masters, Inc., 4412 S. Lawndale Ave., Lyons, Ill.
★Hochman Plastics Machinery Corp., 151 Mulberry St., Newark 2, N. J.
Hoffman Industries, Inc., 345 E. Main St., Spring Arbor, Mich.
★Hofmann & Schwabe K.G., Wilhelmshofallee 96, Krefeld, West Germany
★Holland, M. Co., 956 W. Huron St., Chicago 22, Ill.
Hollywood Plastics, Inc., 4560 Worth St., Los Angeles 63, Calif.
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Holstein, Lee, Injection Molding, Inc., 53 Orchard St., Clifton, N. J.
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★Hommel, O., Co., P. O. Box 475, Pittsburgh 30, Pa.
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★Hopp Plastics, Div. of The Hopp Press, Inc., 460 W. 34th St., New York 1, N. Y.
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Hotwatt, Inc., 75 Maple St., Danvers, Mass.
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Hughes Glue Co., 3500 St. Aubin, Detroit 7, Mich.
Hughes, Henry, Industrial Designer, 1440 Old Country Road, Belmont, Calif.
Hughes Plastics, Inc., 713-721 Pleasant St., St. Joseph, Mich.
★Hull Corp., 1941 Woodland Rd., Hatboro, Pa.
★Hull-Standard Corp., Hatboro, Pa.
Hummel Chemical Co., Inc., 90 West St., New York 6, N. Y.
Hungerford Plastics Corp., Hanover Ave., Morristown, N. J.
Hunt, Rodney, Machine Co., 130 Mill St., Orange, Mass.
Hupp Engineering Assoc., P. O. Box 3290, Sarasota, Fla.
★Hurlbut Paper Co., S. Lee, Mass.
Huxtable, L. Garth, 46 E. 76th St., New York 21, N. Y.
★Hyde Co., A. L., Main St., Grenloch, N. J.
★Hydraulic Press Mfg. Co., The, Div. of Koehring Co., Marion Rd., Mt. Gilead, Ohio
Hydrawlik, 131 E. 1st Ave., Roselle, N. J.
Hydro-Chemie, Ltd., Claridenhof, Dreikonigstrasse 21, Zurich, Switzerland. U. S. Rep.: Conapac Corp., 120 E. 13th St., New York, N. Y.
Hydro Molding Co., Inc., 100 Sharron Ave., Plattsburg, N. Y.
Hy-Sil Mfg. Co., Spring & Prospect Aves., Revere 51, Mass.

I

I-V Die Mold Co., 100 Walnut St., Peoria, Ill.
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Illinois Testing Laboratories, Inc., 420 N. LaSalle St., Chicago 18, Ill.
★Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1, England. U. S. Distributor: J. B. Henriques, Inc., 521 Fifth Avenue, New York 17, N. Y.
★Imperial Chemical Industries (Hyde), Ltd., Sub. of Imperial Chemical Industries, Ltd., Newton Works, Hyde, Cheshire, England
Imperial Color Chemical & Paper Corp., Pigment Color Div., Lower Warren St., Glens Falls, N. Y.
Imperial Industries, Inc., 4436 Walker Ave., Wayne, Mich.
★Improved Machinery, Inc., 150 Burke St., Nashua, N. H.
Independent Die & Supply Co., 2641 LaSalle St., St. Louis 4, Mo.
Independent Machine Co., The, Munroe Falls Ave., Cuyahoga Falls, Ohio
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Induction Motors Corp., 570 Main St., Westbury, N. Y.
Industrial Coatings Co., 907 Roosevelt Ave., York, Pa.
Industrial Development Laboratories, Inc., 982 River Rd., Edgewater, N. J.
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Industrial Engineering Service, Washington St., S. Easton, Mass.
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Industrial Heater Co., Inc., 417 Canal St., New York 13, N. Y.
★Industrial Mfg. Corp., 31 E. Georgia St., Indianapolis 4, Ind.
Industrial Marking Equipment Co., Inc., 655 Berriman St., Brooklyn 8, N. Y.
★Industrial Molded Products Co., Inc., Highway 53 at U.S. 14, Palatine, Ill.
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★Industrial Ovens, Inc., 13825 Triskett Rd., Cleveland 11, Ohio
Industrial Plastic Coating Corp., 83 Wabash Ave., Clifton, N. J.
Industrial Plastic Co., 216 Tingley Lane, Metuchen, N. J.
Industrial Plastic & Equipment Co., 144 Elmora Ave., Elizabeth, N. J.
Industrial Plastic Fabricators, Endicott St., Norwood, Mass.
Industrial Plastic Supply Div., Industrial Safety Supply Co., Inc., 574 New Park Ave., W. Hartford 10, Conn.
Industrial Plastics Corp., 816 W. Beardsley St., Elkhart, Ind.
Industrial Plastics, Inc., 1351 W. 73rd St., Cleveland 2, Ohio
Industrial Plastics, Ltd., 93 Regent St., London W.1, England
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Industrial Vibrator & Machinery Co., 1485 Bayshore Blvd., San Francisco, Calif.
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Ingwersen Mfg. Co., Inc., 1870 S. Acoma St., Denver 23, Colo.
★Injection Molders Supply Co., 3514 Lee Rd., Cleveland 20, Ohio
Injection Molding Co., 75th & Cleveland Sts., Kansas City 30, Mo.
Injection Molding Corp., 115 Fourth Ave., New York 3, N. Y.
Inland Container Corp., 700 W. Morris St., Indianapolis 6, Ind.
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Insulating Fabricators of New England, Inc., 69 Grove St., Watertown 72, Mass.
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Interchemical Corp., Finishes Div., 224 McWhorter St., Newark 5, N. J.
Interchemical Corp., Printing Ink Div., 67 W. 44th St., New York 36, N. Y.
International Balsa Corp., 100 Boyd Ave., Jersey City 4, N. J.
★International Basic Economy Corp., The Sinclair-Collins Valve Co. Div., 454 Morgan Ave., Akron 11, Ohio
International Eastern Co., 801 Sixth Ave., New York 1, N. Y.
International Engineering Inc., 1266 Bolander Ave., Dayton 1, Ohio
International Engraving Corp., Grove & Rutgers Aves., Cedar Grove, N. J.
International Filler Corp., 100 Bridge St., N. Tonawanda, N. Y.
International Plastic Co., 1950 Third Ave., New York 29, N. Y.
International Textile Co., 2600 N. Pulaski Rd., Chicago 39, Ill.
International Vulcanizing Corp., 104 Brookline Ave., Boston 15, Mass.
★Interplastics Corp., 120 E. 56th St., New York 22, N. Y.
Intraplast Mfg. Co., 50 Broad St., New York 4, N. Y.
Ion Exchange & Chemical Corp., 48 Leonard St., New York 13, N. Y.
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Island Equipment Corp., 1090 E. 31st St., Hialeah, Fla.
Isochem Resins Corp., 221 Oak St., Providence 9, R. I.
Isocyanate Products, Inc., 900 Wilmington Rd., New Castle, Del.

J

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Jamison Plastic Corp., 1255 Newbridge Rd., N. Bellmore, N. Y.
Java Latex & Chemical Corp., 1713 W. Farms Rd., New York 60, N. Y.
Jay Moulding Corp., 7 Bridge Ave., Cohoes, N. Y.
★Jay, T. V. Co., 2227 W. Belmont Ave., Chicago 18, Ill.
Jayron Corp., 300 Hamilton St., Leominster, Mass.
Jefferson Chemical Co., 1121 Walker Ave., Houston 2, Texas
Jema-American, Inc., 181 South St., Newark 5, N. J.
Jennings Engineering Co., 3444 Ludlow St., Philadelphia 4, Pa.
★Jessall Plastics, Inc., 889 Farmington Ave., Kensington, Conn.
Jet Specialties Co., Inc., 941 N. Eastern Ave., Los Angeles 63, Calif.
Joanna Western Mills Co., 2141 S. Jefferson St., Chicago 32, Ill.
Joclin Mfg. Co., Lufbery Ave., Wallingford, Conn.
Jodee Plastics Co., 36 Crescent St., Brooklyn 8, N. Y.
★Johns-Manville, 22 E. 40th St., New York 16, N. Y.
Johnson Glass & Plastic Corp., 5248 Elston Ave., Chicago 30, Ill.
★Johnson Machinery Co., 683 Frelinghuysen Ave., Newark 5, N. J.
★Johnson Mfg. Co., Inc., Highway, 178, Chippewa Falls, Wis.
Johnstone Engineering & Machine Co., First Ave. & Gay St., Atglen, Pa.
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Jomac, Inc., 6128 N. Woodstock, Philadelphia 38, Pa.

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Jones Motrola Corp., 432 Fairfield Ave., Stamford, Conn.
Just Plastics, Inc., 250 Dyckman St., New York 34, N. Y.

K

Kabar Mfg. Corp., 1907 White Plains Rd., New York 62, N. Y.
Kal Plastics, Inc., P. O. Box 236, Beaverton, Mich.
Kalle & Co., A.G., Wiesbaden, West Germany. U. S. Rep.: David S. Greenfield, 3143 Decatur Ave., Bronx 67, N. Y.
Karlstad, Andrew C., 4146 Ventura Canyon Ave., Sherman Oaks, Calif.
★Karlton Machinery Corp., 210 E. Ohio St., Chicago 11, Ill. (Rep. for Becker & Van Hullen)
★Kassel Export Co., 108 S. Van Brunt St., Englewood, N. J.
★Kato Seisakusho Co., Ltd., 70, 4-chome, Higashi Magome-machi, Ohta-ku, Tokyo, Japan
Kaufman Glass Co., Plastics Div., 1209-21 French St., Wilmington 99, Del.
Kaumagraph Co., 14th & Poplar Sts., Wilmington 99, Del.
Kautex-U. S. Sales Co., Inc., 133-10—32nd Ave., Flushing 54, N. Y.
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Kay-Fries Chemicals, Inc., 180 Madison Ave., New York 16, N. Y.
Kaye, Chris, Plastics Mfg. Co., 1200 Madison Ave., Madison, Ill.
Kaykor Industries, Inc. 4391 S. Broad St., Yardville, N. J.
Keck, Henry, Associates, 245 Fair Oaks Ave., S. Pasadena, Calif.
Keeler & Long, Inc., 167 Maple St., Waterbury, Conn.
Kehr Products Co., 437 N. Broad St., Philadelphia 8, Pa.
Kel-Min Co., S. Maine, Middlefield, Ohio
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★Kentucky Color & Chemical Co., Inc., Div. of The Harshaw Chemical Co., 600 N. 34th St., Louisville, Ky.
Kenwood Plastics, 5200 River Rd. Washington 6, D. C.
★Keolyn Plastics, Inc., 2731 N. Pulaski Rd., Chicago 39, Ill.
Kerr Industries, 105 W. Spazier Ave., Burbank, Calif.
Kerrco Products, Box 228, Havelock Sta., Lincoln 7, Neb.
Kessler Chemical Co., Inc., State Rd. & Cottman Ave., Philadelphia 35, Pa.
Ketchpel Engineering Co., 1401-04 Palisade Ave., W. Englewood, N. J.
Keyes Fibre Co., College Ave., Waterville, Maine
Keystone Packaging Service, 1012 Washington St., Easton, Pa.
Keystone Plastics, Inc., 280 Badger Ave., Newark 8, N. J.
Keystone Refining Co., Inc., 4821-31 Garden St., Philadelphia 37, Pa.
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Kingsbacher Murphy Co., 9830 Bellanca Ave., Los Angeles 45, Calif.
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Kish Industries, Inc., 1301 N. Turner St., Lansing 6, Mich.
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Knoedler Chemical Co., 651 High St., Lancaster, Pa.
Knuth Engineering Co., 2617 N. St. Louis St., Chicago 47, Ill.
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Kohnstamm, H., & Co., Inc., 161 Ave. of the Americas, New York 13, N. Y.
Kolker Chemical Corp., 600 Doremus Ave., Newark 5, N. J.
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★Koppers Co., Inc., Plastics Div., Koppers Bldg., Pittsburgh 19, Pa.
Koppers Co., Inc. Plastics Div., Durethene Dept., 7001 W. 60th St., Chicago 38, Ill.
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Kordite Corp., Macedon, N. Y.
★Korris Products, Inc., 4400 Lawndale Ave., Lyons, Ill.
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Kramer, H. W., Co., Inc., 120-30 Jamaica Ave., Richmond Hill 18, N. Y.
Kreidl Chemico Physical Co., The, 956 Fifth Ave., New York 21, N. Y.
Kreier, Jr., George, Inc., 1524 Cambridge St., Philadelphia 30, Pa.
★Krieger Color & Chemical Co., Inc., 6531 Santa Monica Blvd., Hollywood 38, Calif.
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Kunst, John, Co., The, 41 Murray St., New York 7, N. Y.
★Kurz-Kasch, Inc., 1421 S. Broadway, Dayton 1, Ohio
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Kwik-Mold Plastic Corp., 247 W. 67th St., New York 23, N. Y.

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Lake Erie Plastics Co., 140 Woodbury St., Elyria, Ohio
Lakeside Plastics Corp., P. O. Box 1007, Oshkosh, Wis.
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Laminated Sheet Products Corp., 440 Neponset St., Norwood, Mass.
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Lemmon & Snoap Co., 2618 Thornwood, Grand Rapids 9, Mich.
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Leslie Co., 214 Leslie Bldg., Lyndhurst, N. J.
★Lester Engineering Co., 2711 Church Ave., Cleveland 13, Ohio
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Milwaukee Plastics, Inc., 4044 N. 31st St., Milwaukee 16, Wis.
Mineralite Sales Corp., P. O. Box 311, 231 Mineola Blvd., Mineola, N. Y.
★Minerals & Chemicals Corp. of America, 59 Essex Turnpike, Menlo Park, N. J.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave., S., Minneapolis 8, Minn.
Minneapolis Plastic Molders, Inc., 5742 Nicollet Ave., Minneapolis 19, Minn.
Minnesota Mining & Mfg. Co., Adhesive, Coating & Sealer Div., 900 Bush Ave., St. Paul 6, Minn.
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N

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Nashua Corp., 44 Franklin St., Nashua, N. H.

National Aluminate Corp., 6229 W. 66th Pl., Chicago 38, Ill.

★National Automatic Tool Co., Inc., S. 7th & N Sts., Richmond, Ind.

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★National Lock Co., 1902 Seventh St., Rockford, Ill.

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★National Plastic Products Co., The, 100 McPhail St., Odenton, Md.

National Plastics, Inc., 2326-30 McCalla Ave., Knoxville 1, Tenn.

National Plasticrafters, Inc., 1822 Martin Ave., Sheboygan, Wis.

★National Polychemicals, Inc., Eames St., Wilmington, Mass.

National Polymer Products, Inc., Sub. of The Polymer Corp., 125 N. Fourth St., Reading, Pa.

★National Rubber Machinery Co., Plastics Machinery Div., 47 W. Exchange St., Akron 8, Ohio

National Starch & Chemical Corp., 750 Third Ave., New York 17, N. Y.

★National Tool & Mfg. Co., 100 N. 12th St., Kenilworth, N. J.

National Vacuum Platers, Inc., 2635 E. Hagert St., Philadelphia 25, Pa.

National Vulcanized Fibre Co., Maryland Ave. & Beech Sts., Wilmington 99, Del.

Natvar Corp., 211 Randolph Ave., Woodbridge, N. J.

★Naugatuck Chemical, Div. of U. S. Rubber Co., Elm St., Naugatuck, Conn.

★Negri Bossi & C., Via Bazzini, 24, Milan, Italy

★Newark Die Co., 24 Scott St., Newark 2, N. J.

★Newark Die Hobbing & Casting Co., 20 Scott St., Newark 2, N. J.

★Newbury Industries, Inc., Route 87, Newbury, Ohio

★New England Butt Co., 304 Pearl St., Providence, R. I.

New England Die Co., Inc., 64 Floral St., Taunton, Mass.

New England Laboratories, Inc., County Rd., Ipswich, Mass.

★New England Laminates Co., Inc., 481P Canal St., Stamford, Conn.

New England Lime Co., Adams, Mass.

New England Tank & Tower, 99 Tileston St., Everett 49, Mass.

New England Tape Co., 30 Tower St., Hudson, Mass.

★New Hermes Engraving Machine Corp., 154 W. 14th St., New York 11, N. Y.

New Jersey Machine Corp., 16th & Willow Sts., Hoboken 1, N. J.

New Jersey Thermex Co., Inc., 531 Bergen St., Harrison, N. J.

New Jersey Zinc Co., The, 160 Front St., New York 38, N. Y.

Newport Industries Co., Div. of Heyden Newport Chemical Corp., 342 Madison Ave., New York 17, N. Y.

Newport Plastics Corp., Derby Rd., Newport, Vt.

Niagara Machine & Tool Works, 637-697 Northland Ave., Buffalo 11, N. Y.

Niagara Plastics Co., R. D. #3, Edinboro Rd., Erie, Pa.

Nichols Products Co., Inc., 325 W. Main St., Moorestown, N. J.

Nikolas, G. J., & Co., Inc., 2808 Washington St., Bellwood, Ill.

Niles Corp., 50941 U.S. #31, S. Bend 17, Ind.

★Nixon Nitration Works, Nixon, N. J.

★Nopco Chemical Co., 175 Schuyler Ave., N. Arlington, N. J.

Norco Plastic, Inc., 3888 N. Fratney St., Milwaukee 12, Wis.

Norman Plastics, Inc., 106 E. 19th St., New York 3, N. Y.

North American Asbestos Corp., Rm. 3210, Board of Trade Bldg., 141 W. Jackson St., Chicago 8, Ill.

North American Products Corp., 707 Bartley St., Box 291, Jasper, Ind.

Northeastern Plastics, Inc., 215 A St., Boston 10, Mass.

Northern Plastics Corp., 2nd & Market St., La Crosse, Wis.

North Star Industries, Inc., 1900 Second St. So., Hopkins, Minn.

★Northwest Plastics, Inc., 65 E. Plato Ave., St. Paul 7, Minn.

Northwest Plastics Industries, Inc., 1220 E. Cherry St., Seattle 22, Wash.

Norton Co., 1 New Bond St., Worcester 6, Mass.

★Norton Laboratories, Inc., Sub. of Auburn Plastics, Inc., Lockport, N. Y.

Nosco Plastics, Inc., 1701 Gaskell Ave., Box 269, Erie, Pa.

Novelty Bias Binding Co., Plastics Div., 11 Webster Ave., Chelsea, Mass.

Novo Div., Industrial Enterprises, Inc., 9705 S. Cottage Grove, Chicago 28, Ill.

Nu-Engineering, Inc., 1515 Bonner Ave., Ferndale 20, Mich.

Numa Plastics Corp., 4 E. 52nd St., New York 22, N. Y.

★Nuodex Products Co., Div. of Heyden Newport Chemical Corp., Box 242, Elizabeth, N. J.

Nureco, Inc., 1100 Pontiac Ave., Cranston 10, R. I.

Nutmeg Chrome Corp., 111 Vanderbilt Ave., W. Hartford 10, Conn.

Nyloncraft, Inc., 218 McKinley Highway W., Mishawaka, Ind.

Nylon Molding Corp., 143 South Ave., Garwood, N. J.

O

Oak Engineering Co., Inc., 110 Monmouth St., Gloucester City, N. J.

Oakite Products, Inc., 46D Rector St., New York 6, N. Y.

Oakley Die & Mfg. Co., Inc., The, 4426 Brazee St., Cincinnati 9, Ohio

Ohio Adhesives Corp., Maple Ave., Extension, New Philadelphia, Ohio

Ohio Knife Co., The, Dreman Ave. & B & O RR, Cincinnati 23, Ohio

Ohio Lime Co., Woodville, Ohio

Ohio Plastic Co., The, Frazeysburg, Ohio

Oilgear Co., The, 1560 W. Pierce St., Milwaukee 4, Wis.

Olin Mathieson Chemical Corp., Chemicals Div., Mathieson Bldg., Baltimore 3, Md.

Olin Mathieson Chemical Corp., Packaging Div., 655 Madison Ave., New York 21, N. Y.

Oliver Corp., The, A. B. Farquhar Div., 142 N. Duke St., York, Pa.

★Olsenmark Corp., 124-132 White St., New York 13, N. Y.

Olympic Plastics Co., Inc., 3471 S. La Cienga Blvd., Los Angeles 16, Calif.

Omaha Plastics Co., 1470 S. 16th St., Omaha 8, Neb.

★Omni Products Corp., 460 Fourth Ave., New York 16, N. Y.

Onyx Oil & Chemical Co., 190 Warren St., Jersey City 2, N. J.

Opel, von, Georg, Corp., 15 William St., New York 5, N. Y. U. S. Rep. for Dyanmit-Actien-Gesellschaft, (vormals Alfred Nobel & Co.), Troisdorf/Koln, West Germany

Oppenheimer Corp., 578-86 Exchange St., Buffalo 10, N. Y.

Optics Mfg. Corp., Amber & Willard Sts., Philadelphia 34, Pa.

★Orange Products, Inc., 554 Mitchell St., Orange, N. J.

Ormond Mfg. Co., Inc., 313 W. 37th St., New York 18, N. Y.

Orna Plastics Co., 8583 Venice Blvd., Los Angeles 34, Calif.

Oronite Chemical Co., 200 Bush St., San Francisco 20, Calif.

Osborn, C. J., Co., 1301 Blancke St., Linden, N. J.

O'Sullivan Rubber Corp., Valley Pike, Winchester, Va.

Ott, Joseph M. P., Mfg. Co., Inc., 87 Sabin St., Pawtucket, R. I.

Owens-Corning Fiberglas Corp., Reinforced Plastic Div., 717 Fifth Ave., New York 22, N. Y.

Owens-Illinois Glass Co., Multiwall Bag Div., P. O. Box 1035, Toledo 1, Ohio

Owens-Illinois Glass Co., Paper Products Div., P. O. Box 1035, Toledo 1, Ohio

Owens-Illinois Glass Co., Plastics Div., P. O. Box 1035, Toledo 1, Ohio

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Pace, F. D., Co., 1725 Stehouwer, N.W., Grand Rapids 4, Mich.
Pacific Plastics Co., Inc., 4517–14th St., N.W., Seattle 4, Wash.
Packaging Industries, Ltd., Inc., 151 Pine St., Montclair, N. J.
Packless Metal Hose, Inc., 730 S. Columbus Ave., Mt. Vernon, N. Y.
Palfy Die & Mold Co., The, 2900 Bradwell Ave., Cleveland 29, Ohio
Palisades Plastics Mfg. Co., Inc., 178 S. Van Brunt St., Englewood, N. J.
Palmer, Homer W., & Co., 515 N. Halsted St., Chicago 22, N. Y.
Palnut Co., The, 33 Glen Rd., Mountainside, N. J.
Pam Co., 1951 N.W. Wilson St., Portland 9, Ore.
Pamarco, Inc., 235 E. 11th Ave., Roselle, N. J.
Pangborn Corp., 4100 Pangborn Blvd., Hagerstown, Md.
Pantasote Co., The, 26 Jefferson St., Passaic, N. J.
★Pantex Mfg. Co., 520 Roosevelt Ave., Pawtucket, R. I.
Paper Products Development, 453 W. 17th St., New York 11, N. Y.
Paragon Plastic Corp., 295 Lafayette St., New York 12, N. Y.
Paralite Mfg. Co., 1466 F St., San Diego 2, Calif.
Paramount Foam Industries, 525 Oritan Ave., Ridgefield, N. J.
Para Products Div., Foundry Rubber, Inc., 5200 River Rd., Washington 16, D. C.
Parcloid Chemical Co., 31 Cross Ave., Midland Park, N. J.
Parco Co., 191 South St., Newark 5, N. J.
Park Plastics Co., 104 E. Elizabeth Ave., Linden, N. J.
Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio
Parker-Kalon Div., General American Transportation Corp., 1 Peekay Dr., Clifton, N. J.
Parker Plastics Corp., Box 10326, Pittsburgh 34, Pa.
Parkwood Laminates, Inc., 24 Water St., Wakefield, Mass.
Partlow Corp., The, 225 Campion Rd., New Hartford, N. Y.
Pasadena Hydraulics, Inc., 1433 Lidcombe Ave., El Monte, Calif.
Pasley's Plastic Products, Inc., 1275 Ellsworth Industrial Dr., N.W., Atlanta 18, Ga.
Pasquetti, Carlo, & C., S.A.S., Fabbrica Prodotti Termoplastici, Via Sanvito Silvestro 103, Varese-Masnago, Italy
Patent Button Co. of Tennessee, Inc., The, 2200 Century St., Knoxville 1, Tenn.
Paterson Parchment Paper Co., Bristol, Pa.
Patron Transmission Co., Inc., 129 Grand St., New York 13, N. Y.
Patterson Foundry & Machine Co., The, 1250 St. George St., E. Liverpool, Ohio
Patterson-Kelley Co., Inc., The, E. Stroudsburg, Pa.
Patzig Testing Laboratories, 2215 Ingersoll Ave., Des Moines 12, Iowa

Payne Tool & Engineering Co., The, 1300 W. Columbia St., Springfield, Ohio
Pearson Industries, 27-10–44th Dr., Long Island City 1, N. Y.
Pearson-Sutton Corp., 18 N. State St., Newtown, Bucks County, Pa.
★Peco Machinery Sales (Westminster), Ltd., 28 Victor St., London, S.W.1, England
★Pecorp, Inc., Basin Rd., P. O. Box 3164, Wilmington 4, Del.
Peerless Chemical Corp., Verplanck, N. Y.
Peerless Molded Plastics, Inc., 401 Hamilton St., Toledo 2, Ohio
Peerless Plastics, 8490 Warner Dr., Culver City, Calif.
Peerless Plastics Co., Inc., 13520 W. Reichert Ave., P. O. Box 25, Butler, Wis.
★Peerless Roll Leaf Co., Inc., 4511 New York Ave., Union City, N. J.
Pellon Corp., 350 Fifth Ave., New York 1, N. Y.
Pelmor Laboratories, Inc., 401 Lafayette St., Newtown, Pa.
Pelron Corp., 7847 W. 47th St., Lyons, Ill.
Penick, S. B., & Co., 100 Church St., New York 8, N. Y.
Pen Mac Nye Co., The, 1056 Home Ave., Akron 10, Ohio
Penn-Plastics Corp., Fairhill Ave., Glenside, Pa.
Pennsalt Chemicals Corp., 3 Penn Center, Philadelphia 2, Pa.
Pennsylvania Color & Chemical Co., Pine Run Rd., Doylestown, Pa.
Pennsylvania Fluorocarbon Co., Inc., 1115 N. 38th St., Philadelphia 4, Pa.
Pennsylvania Industrial Chemical Corp., 120 State St., Clairton, Pa.
Pennsylvania Pump & Compressor Co., Bushkill Dr., Easton, Pa.
Pennsylvania Refining Co., 2686 Lisbon Rd., Cleveland 4, Ohio
Peoria Plastic Co., 215 Taylor Ave., E. Peoria, Ill.
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Perfecting Service Co., 332 Atando Ave., Charlotte 6, N. C.
Perfex Plastics, Inc., 2632 S. Dearborn St., Chicago 16, Ill.
★Perforated Specialties Co., 351 W. 35th St., New York 1, N. Y.
★Perforating Industries, Inc., 336-338 W. Westfield Ave., Roselle Park, N.J.
Perkins Glue Co., 632 Cannon Ave., Lansdale, Pa.
Permacel, U.S. Highway #1, New Brunswick, N. J.
Permanent Label Corp., 49 Ackerman St., Bloomfield, N. J.
Perma Seal Plastic Products Co., 1821 University Ave., St. Paul 4, Minn.
Perry Plastics, Inc., 3409 W. 14th St., Erie, Pa.
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★Peterson, A. W., & Sons Die Co., Inc., 131 Prince St., New York 12, N. Y.
Peterson, J. E., Research and Development, 42-25–80th St., Elmhurst, N. Y.
Peterson Spray Gun Co., 1751 Leslie St., San Mateo, Calif.
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Pheoll Mfg. Co., Inc., 5700 Roosevelt Rd., Chicago 50, Ill.

Philadelphia Quartz Co., 1146 E. Public Ledger Bldg., Philadelphia 6, Pa.
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Photomation, Inc., 96 S. Washington Ave., Bergenfield, N. J.
Pierce & Stevens Chemical Corp., 710 Ohio St., Buffalo 3, N. Y.
Pierce Wrapping Machine Co., 1100 E. 31st St., LaGrange Park, Ill.
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Pikes Peak Plastics, Inc., 109 S. Conejos St., Colorado Springs, Colo.
Pine-Wood Plastic Co., Inc., 245 Sixth St., Cambridge 42, Mass.
Pioneer Lacquer Corp., McCarthy Ave., Cherry Valley, Mass.
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Pitman Plastic Products, Inc., 55 Commercial Ave., Pitman, N. J.
Pitt-Consol Chemical Co., 191 Doremus Ave., Newark 5, N. J.
★Pittsburgh Plate Glass Co., Fiber Glass Div., 1 Gateway Center, Pittsburgh, Pa.
Pittsburgh Plate Glass Co., Paint Div., 632 Ft. Duquesne Blvd., Pittsburgh 22, Pa.
Planet Plating Co., Inc., 494 Morgan Ave., Brooklyn 22, N. Y.
Plano Molding Co., 113 S. Center Ave., Plano, Ill.
Plaskolite, Inc., 22 Neilston St., Box 1497, Columbus 15, Ohio
Plast-Ad Mfg. Co., 222 N. Michigan St., South Bend, Ind.
Plas-Tech Equipment Corp., 751 Main St., P. O. Box #4, Waltham 54, Mass.
Plaster Supply House, P. O. Box 551, Chicago 90, Ill.
Plastex Co., The, 3232 Cleveland Ave., Columbus 24, Ohio
Plastex Laminates, Inc., 1000 E. 26th St., Hialeah, Fla.
Plastex Process Co., 230 W. Passaic St., Maywood, N. J.
Plastic Academy Products Corp., 345 Central St., Leominster, Mass.
Plastic Age Sales, Inc., 14300 Davenport Rd., Saugus, Calif.
Plastic Artisans, Inc., Dock St. & Martin Pl., Port Chester, N. Y.
Plastic Art Metallizing Corp., 68-70 Freeman St., Brooklyn 22, N. Y.
Plastic Center, 127 W. Water St., Rochester 4, N. Y.
Plastic Corp. of Chicago, 8722 W. 47th St., Lyons, Ill.
Plastic-Craft Corp., 1 Station Plaza, W. Nyack, N. Y.
Plastic Engineering Co., Dunnell Lane, Pawtucket, R. I.
Plastic Engineering Co. of Tulsa, 510 N. Sheridan, Tulsa, Okla.
Plastic Engineering & Sales Corp., 2628 St. Louis Ave., Fort Worth, Texas
Plastic Enterprises, 124-14–22nd Ave., College Point 56, N. Y.
Plastic Extruded Products Co., 309 Port Ave., Elizabeth 1, N. J.
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Plastic Inlays, Inc., 282 Broad St., Summit, N. J.
Plastic Laminating Co., Wallingford Rd., Swarthmore, Pa.
Plastic Laminating Corp., 2087 Springfield Ave., Vauxhall, N. J.
Plastic Machinery Exchange, 426 Essex Ave., Boonton, N. J.
Plastic Masters, Inc., U.S. 12 West, New Buffalo, Mich.
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Plastic Model Engineering, 14530 Arminta St., Van Nuys, Calif.
Plastic Mold & Die Co., 308 S. 3rd St., Darby, Pa.
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Plastic Mold Tool & Die Co., Inc., 1 Maple St., E. Rutherford, N. J.
Plastic Molded Products Co., 6044 N. Pulaski Rd., Chicago 46, Ill.
★Plastic Molders Supply Co., Inc., 74 South Ave., Fanwood, N. J.
Plastic Molding Powders, Inc., 2004 McDonald Ave., Brooklyn 23, N. Y.
Plastic Moldings Corp., 859 Hathaway St., Cincinnati 3, Ohio
Plastic Papers, Inc., 210 Miller Rd., Hicksville, N. Y.
Plastic Parts Corp., 2425 Ryan Rd., Maumee, Ohio
Plastic Precision Parts Co., 4912 W. Grand Ave., Chicago 39, Ill.
Plastic Process Co., Div. of Monadnock Mills, 11200 Hindry Ave., Los Angeles 45, Calif.
Plastic Products Corp., 24001 Aurora Rd., Bedford Heights, Ohio
Plastic Products, Inc., Pine St., S. Norwalk, Conn.
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Plastic Rotocast Co., 703 S. LaSalle St., Chicago 5, Ill.
Plastic Scrap Materials, P. O. Box 31, East Rochester, N. Y.
Plastic Service Corp., 515 Boston St., Laporte, Ind.
Plastic Service Corp., 225 Fifth Ave., New York 10, N. Y.
★Plastic Stamping & Molding Corp., 2232 W. Armitage Ave., Chicago 47, Ill.
Plastic Suppliers & Mfrs., 1635 Scenic Highway, Baton Rouge, La.
Plastic Toys Corp., Main St., Byesville, Ohio
Plastic Welding Corp., 780 Frelinghuysen Ave., Newark 12, N. J.
Plasticite Corp., 321 Rider Ave., New York 51, N. Y.
Plasticles Corp., 14590 Schaefer Rd., Detroit 27, Mich.
Plastico, 3200 W. 3rd St., Dayton 17, Ohio
Plasticraft Mfg. Co., 287 Laurel Ave., Kearny, N. J.
Plastics Center of Texas, 317 Nogalitos St., San Antonio 4, Texas
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Plastics Consultant Service, 155 E. 40th St., New York 16, N. Y.
★Plastics Engineering Co., 1607 Geele Ave., Sheboygan, Wis.
Plastics by Hoover, 203–19th St., Huntington 3, W. Va.
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Plectron Corp., Overton, Neb.
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Polycast Corp., The, 69 Southfield Ave., Stamford, Conn.
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Polyform Plastics Corp., 24 University Pl., New York 3, N. Y.
★Polygon Plastics Co., Walkerton, Ind.
Polyken Sales Div., The Kendall Co., 309 W. Jackson Blvd., Chicago 6, Ill.
Polykote, Inc., 877 Addison Rd., Cleveland 3, Ohio
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★Polymer Corp., The, 2120 Fairmont Ave., Reading, Pa.
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Polymold Plastics, Inc., 3417 N. Western Ave., Chicago 18, Ill.
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Polytex Industrial Finishes Corp., Affiliate of Atlas Coatings Corp., 5-31–47th Ave., Long Island City 1, N. Y.
Polyvinyl Chemicals, Inc., 26 Howley St., Peabody, Mass.
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Porter-Cable Machine Co., 700 Marcellus St., Syracuse 4, N. Y.
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Portland Co., The, 58 Fore St., Portland, Maine
Portz Plastics & Fibre Co., 411 N. 3rd St., Milwaukee 3, Wis.
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★Possis Machine Corp., 1645 Hennepin Ave., Minneapolis 3, Minn.
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Powell, Jim, Industrial Designers, 6351 Wilshire Blvd., Los Angeles 48, Calif.
Powers Regulator Co., The, 3400 Oakton St., Skokie 34, Ill.
★Powhatan Mining Co., 6721 Windsor Mill Rd., Baltimore 7, Md.
Pratt & Whitney Co., Inc., Charter Oak Blvd., W. Hartford 1, Conn.
Preble, Jr., Harry, Industrial Designer, Schoolhouse Rd., Cross River, N. Y.
Precision Molded Plastics, Inc., 2014 W. 53rd St., Cleveland 2, Ohio
Precision Plastics Co., 4655 Stenton Ave., Philadelphia 44, Pa.
Precision Products Co., Inc., 252 E. 16th St., Paterson, N. J.
★Preis, H. P., Engraving Machine Co., 651 U.S. Highway 22, Hillside 5, N. J.
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Premier Plastic Co., 204 W. Washington St., Milwaukee 4, Wis.
Premier Thermo Plastics Co., Middletown Rd., Jeffersontown, Ky.
★Premier Vacuum Process Corp., 58-87–55th St., Maspeth 78, N. Y.
Presco Plastics, 121 N. Broadway, Milwaukee 1, Wis.
Preservation Packaging, Inc., 1407 Chestnut Ave., Hillside, N. J.
★Presque Isle Plastics, Inc., 2730 W. 12th St., Erie 12, Pa.
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Price Brothers Corp., 38 Austin St., Worcester 8, Mass.
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Printloid, Inc., 10-06—44th Ave., Long Island City 1, N. Y.
Printon Corp., 310 E. 23rd St., New York 10, N. Y.
Process Engineering & Machine Co., Inc., 442 York St., Elizabeth 4, N. J.
★Process Gear Co., 4616 W. Fullerton, Chicago 39, Ill.
Process Mold Co., 19665 Schoenherr Ave., Detroit 5, Mich.
Proctor & Schwartz, Inc., 7th St. & Tabor Rd., Philadelphia 20, Pa.
Procunier Safety Chuck Co., 18 S. Clinton St., Chicago 6, Ill.
Prodel, S. A., Societe De Produits Industriels, 58, Avenue de Versailles, Paris 16, France (U.S. Rep.: Ferber Trading Corp., 42 W. 33rd St., New York 1, N. Y.)
★Prodex Corp., King George Rd., Fords, N. J.
Product Engineering & Development Co., 9 N. Tyler Ave., Hopkins, Minn.
Product Packaging Engineering, 5713 Joanne Pl., Culver City, Calif.
★Progressive Machine Co., Inc., 167-169 E. 31st St., Paterson 4, N. J.
Progressive Molded Products Corp., 1100 S. Morgan St., Bluffton, Ind.
Progressive Plastics Mfg. Corp., 175 E. 153rd St., Bronx 51, N. Y.
Prolon Plastics, 221 Pine St., Florence, Mass.
Protective Lining Corp., 22 Woodhull St., Brooklyn 31, N. Y.
Protective Treatments, Inc., 420 Dellrose Ave., Dayton 3, Ohio
Prufcoat Laboratories, Inc., 63 Main St., Cambridge 42, Mass.
Pulva Corp., 550 High St., Perth Amboy, N. J.
Pulverizing Machinery Div., Metals Disintegrating Co., Inc., 30 Chatham Rd., Summit, N. J.
Putnam Chemical Corp., Beacon, N. Y.
Pyramid Industrial Finishing Corp. 431-3 Southern Blvd., New York 55, N. Y.
Pyramid Plastics, Inc., 554 W. Polk St., Chicago 7, Ill.
Pyramid Screen Corp., 181 Harvard St., Brookline 46, Mass.
Pyrometer Instrument Co., Inc., 92 Portland St., Bergenfield, N. J.
Pyrometer Service Co., Inc., 348 River Rd., N. Arlington, N. J.
★Pyro Plastic Corp., Pyro Park, Union, N. J.
Pyrotex Co., Inc., 287 Whitney St., Leominster, Mass.
Pyroxylin Products, Inc., 4851 S. St. Louis Ave., Chicago 32, Ill.

Q

Quaker Oats Co., The, Chemical Div., Merchandise Mart Plaza, Chicago 54, Ill.
Queen Products, Inc., 215 Georgia Ave., Providence 5, R. I.
Quelcor, Inc., Front & Broomall Sts., Chester, Pa.
Quick Plastics, 1680 Cooper St., Jackson, Mich.
Quincy Compressor Co., 217 Main St., Quincy, Ill.
★Quinn-Berry Corp., 2906 W. 12th St., Erie, Pa.

R

R. C. Molding, Inc., 112 S. 6th St., New Hyde Park, N. Y.
R.E.C. Mfg. Co., 1250 Highland St., Holliston, Mass.
Racine Hydraulics & Machinery, Inc., 2000 Albert St., Racine, Wis.
Radial Cutter Mfg. Corp., 831 Bond St., Elizabeth 4, N. J.
Radiant Heat Enterprises, Inc., 630 Morris & Essex Turnpike, Short Hills, N. J.
Radiation Applications, Inc., 370 Lexington Ave., New York 17, N. Y.
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Randall Mfg. Co., Inc., 801 Edgewater Rd., New York 59, N. Y.
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★Raybestos-Manhattan, Inc., Reinforced Plastics Dept., Manheim, Pa.
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Rayonier, Inc., 161 E. 42nd St., New York 17, N. Y.
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Reinhold Engineering & Plastics Co., Inc., 12827 E. Imperial Highway, Norwalk, Calif.
Reinhold-Geiger Plastics, Inc., 8763 Crocker St., Los Angeles 3, Calif.
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Superior Materials, Inc., 120 Liberty St., New York 6, N. Y.
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Sylvania Electric Products, Inc., Parts Div., Warren, Pa.
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★Synthetic Products Co., 1636 Wayside Rd., Cleveland 12, Ohio
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